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ABSTRACT

This guide is designed to help teachers in auto collision technician programs for grades 11 and 12 teach the critical competencies of the program. The critical competencies covered are the High Priority-Individual (HP-I) competencies in Ohio's Occupational Competency Assessment Profile (OCAP) for Auto Collision Technician. HP-I competencies are those that require students to demonstrate hands-on competency to the instructor on an individual basis. Teacher materials include program/instructor resources, program basics, additional program elements, and activity options. Units 1-5 cover the following areas (with number of HP-I competencies in parentheses): structural analysis and damage repair (23); non-structural analysis and damage repair (40); mechanical and electrical components (39); plastics and adhesives (5); and painting and refinishing (3 HP-I and 7HP-General). Unit 6 covers basic shop and safety practices. The Competency Development Guides (CDGs) are designed to provide suggestions for how to teach the units and competencies. Each CDG covers one competency (or two or more related competencies) and includes the following information: unit, subunit, and competency number and title; objective; introduction; references; presentation (content outline with key points); review questions; application (student activities); and evaluation (Performance Checklist with directions for use). (YLB)

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Auto Collision Technician

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An Instructional Guide for Teachers

Instruction Tied to the Task List
of the
National Automotive Technicians Education Foundation (NATEF)
for
Automotive Service Excellence (ASE) Certification

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State of Ohio
Department of Education

John M. Goff
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October 30, 1998

To All Auto Collision Instructors:

We are pleased to introduce a resource to you that will add to the quality of your instruction and improve the learning of your students. This resource, *Auto Collision Technician: An Instructional Guide for Teachers*, offers you a wealth of material designed to maximize the effectiveness of your program.

Two important factors contribute to the usefulness of the guide. First, it was designed by your colleagues. A team of auto collision instructors worked diligently to produce a document that specifically meets your needs as well as those of your students. Second, the design team made sure that the requirements of ASE certification and the auto collision OCAP were considered and included wherever possible. The team also included a comprehensive list of reference materials, resources, and instructional techniques, all tried and proven effective by the team members in their everyday instruction.

We hope you will use the guide routinely in your program. In doing so, we are confident you will find it to be most valuable in the planning, delivery, and evaluation of your instruction. This, in turn, will most certainly lead to the ultimate goal of improved student performance.

Sincerely,

Bob Bowermeister

Bob Bowermeister, Assistant Director
Trade and Industrial/Health Occupations
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Contents

About This Guide

Overview ... 3
  What Is Covered ... 3
  Program Organization ... 4
  Using the Competency Development Guides (CDGs) ... 4

Program/Instructor Resources ... 5
  Advisory Committee ... 5
  Sources of Materials and Equipment ... 6
  Sources of Technical Assistance ... 6

Program Basics ... 11
  Safety ... 11
  Tools and Equipment ... 12
  References ... 13
  Organization of Instruction and the Learning Laboratory ... 16
  Rotation Schedules ... 16
  Individual Career Plans (ICPs) and Career Passports ... 18
  Individual Educational Plans (IEPs) ... 19
  Assessment ... 19

Additional Program Elements ... 21
  Customer Service Orientation ... 21
  Professionalism and Maintenance of ASE Certification ... 21
  Vocational Student Organization (VSO) Participation ... 22
  Academic/Vocational Integration ... 22
  Guest Speakers ... 23
  Field Trips ... 24
  Job Shadowing or Mentoring ... 24
  Job Experiences ... 24

Activity Options ... 26

Competency Development Guides

Unit 1: Structural Analysis and Damage Repair
Unit 2: Non-Structural Analysis and Damage Repair
Unit 3: Mechanical and Electrical Components
Unit 4: Plastics and Adhesives
Unit 5: Painting and Refinishing
Unit 6: Basic Shop and Safety Practices

The following chart shows the order in which the Competency Development Guides (CDGs) are presented, as well as what competency or clustered competencies each CDG covers. Unit, subunit, and competency numbers refer to the numbers assigned to the NATEF task list components in Ohio's 1997 Occupational Competency Assessment Profile (OCAP) for *Auto Collision Technician*. Please note:

- The overall skill covered by each CDG (the "behavior" from the CDG objective) is listed (unshaded) immediately below the competency numbers.
- Where two or more NATEF competencies were combined into a single CDG, the overall skill statement is followed by a bulleted list of the NATEF competencies included (shaded).
- Where parts of a single NATEF competency are covered in different CDGs, the parts ***not*** covered in a given CDG are shown in [brackets].
- Where a CDG covers competencies from two or more units, identical copies of that CDG are placed within ***each*** of those units. Teachers in local programs will need to decide in which unit it will be given primary emphasis (or in which initial instruction will occur).

Units	Subunits	Competencies
1	**1.1/1.2**	1.1.1/1.2.2 Diagnose and measure vehicle dimensions and structural damage using tram and self-centering gauges • Diagnose and measure structural damage using tram and self-centering gauges • Diagnose and analyze unibody vehicle length, height, and width using a tram gauge
1	1.2	1.2.6/1.2.17 Determine extent of damage and direction of impact, and plan repair methods/sequence • Determine the extent of the direct and indirect damage and the direction of impact; plan the methods and sequence of repair • Determine the extent of damage to structural steel body panels; repair or replace
1	1.2	1.2.7 Attach body anchoring devices
1	1.2	1.2.16 Remove creases and dents using power tools and hand tools
1 & 2	1.4 & 2.5	1.4.1/2.5.1 & 1.4.3/2.5.3 Determine the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation • Identify weldable and non-weldable materials used in collision repair and refinish components • Determine the correct welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation

Units	Subunits	Competencies
1 & 2	1.4 & 2.5	1.4.2/2.5.2 & 1.4.14/2.5.14 Perform welds • Weld [and cut] high-strength steel and other metals • Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints
1 & 2	1.4 & 2.5	1.4.2/2.5.2 Cut high-strength steel and other metals
1 & 2	1.4 & 2.5	1.4.4/2.5.4–1.4.8/2.5.8 Set up, adjust, operate, and maintain welding equipment • Set up welding equipment • Adjust the welder to "tune" for proper electrode stickout, voltage, polarity, flow rate, and wire-feed speed required for the material being welded • Store, handle, and install high-pressure gas cylinders • Determine work clamp (ground) location and attach • Use the proper angle of the gun to the joint and the direction of the gun travel for the type of weld being made in the flat, horizontal, vertical, and overhead positions
1 & 2	1.4 & 2.5	1.4.9/2.5.9–1.4.11/2.5.11 Prepare a vehicle for welding and cutting operations • Protect adjacent panels, glass, vehicle interior, etc., from welding and cutting operations • Protect computers and other electronic control modules during welding procedures • Clean and prepare the metal for welding; fit, align, and clamp as required
1 & 2	1.4 & 2.5	1.4.12/2.5.12 & 1.4.13/2.5.13 Determine joint type and type of weld for each specific welding operation • Determine the joint type (reinforced-butt, lap, etc.) for weld being made • Determine the type of weld (continuous, reinforced-butt, plug, etc.) for each specific welding operation
1 & 2	1.4 & 2.5	1.4.15/2.5.15 Perform destructive tests on each weld type
1 & 2	1.4 & 2.5	1.4.16/2.5.16 & 1.4.17/2.5.17 Identify causes of welding problems, and make necessary adjustments • Identify the causes of spits and sputters, burn through, lack of penetration, porosity, incomplete fusion, excessive spatter, distortion, and waviness of bead; make necessary adjustments • Identify cause of contact tip burn-back and failure of wire to feed; make necessary adjustments

Units	Subunits	Competencies
2	2.1	2.1.2/2.1.4/2.1.6/2.1.7/2.1.8 Prepare a vehicle for non-structural repair • Inspect, remove, store, and replace exterior trim and moldings • Inspect, remove, and replace non-structural body panels and components that may interfere with or be damaged during repair • Protect panels and parts adjacent to repair area • Remove dirt, grease, and wax from those areas to be repaired • Remove corrosion protection, undercoatings, sealers, and other protective coatings necessary to perform repairs
2	2.2	2.2.1 Determine the extent of direct and indirect damage and direction of impact, and develop a repair plan
2	2.2	2.2.2/2.2.4/2.2.5/2.2.7 Inspect, remove, replace, and align ***bolted*** steel panels or panel assemblies (e.g., hood, deck lid, bumper assembly) and related hardware (e.g., hood/lid hinges, hood/lid latches) • Inspect, remove, and replace bolted, [bonded, and welded] steel panel or panel assemblies • Inspect, remove, replace, and align hood, hood hinges, and hood latch • Inspect, remove, replace, and align deck lid, lid hinges, and lid latch • Inspect, remove, replace, and align bumper bars, covers, reinforcement guards, isolators, and mounting hardware
2	2.2	2.2.2/2.2.6 Inspect, remove, replace, and align ***bonded*** steel panels or panel assemblies (e.g., door outer panels, roof panels) and related hardware (e.g., latches, hinges) • Inspect, remove, and replace [bolted], bonded, [and welded] steel panel or panel assemblies • Inspect, remove, replace, and align doors, tailgates, hatches, lift gates, latches, hinges, and related hardware
2	2.2	2.2.2/2.2.12 Inspect, remove, replace, and align ***welded*** steel panels or panel assemblies • Inspect, remove, and replace [bolted, bonded, and] welded steel panel or panel assemblies • Cut out damaged sections of sheet steel body panels and weld in replacements
2	2.2	2.2.8 Check and align fenders, headers, and other panels

Units	Subunits	Competencies
2	2.2/2.3	2.2.9/2.3.1/2.3.2/2.3.3 Straighten and rough-out contours and reduce surface irregularities on a damaged panel in preparation for body filling or metal finishing • Straighten and rough-out contours of damaged panel to a surface condition for body filling or metal finishing using power tools, hand tools, and stud welder • Remove paint from the damaged area of a body panel • Locate and reduce surface irregularities on a damaged body panel • Demonstrate hammer and dolly techniques
2	2.2	2.2.10 Weld cracked or torn steel body panels, and repair broken welds
2	2.2	2.2.11 Restore corrosion protection
2	2.2	2.2.16 Restore sealers and sound deadeners
2	2.3	2.3.6–2.3.8 Perform body filling procedures • Mix body filler • Apply body filler; cheese-grate during curing • Rough sand cured body filler to contour; finish sand
1 & 2	1.4 & 2.5	1.4.1/2.5.1 & 1.4.3/2.5.3 Determine the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation • Identify weldable and non-weldable materials used in collision repair and refinish components • Determine the correct welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation
1 & 2	1.4 & 2.5	1.4.2/2.5.2 & 1.4.14/2.5.14 Perform welds • Weld [and cut] high-strength steel and other metals • Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints
1 & 2	1.4 & 2.5	1.4.2/2.5.2 Cut high-strength steel and other metals

Units	Subunits	Competencies
1 & 2	1.4 & 2.5	1.4.4/2.5.4–1.4.8/2.5.8 Set up, adjust, operate, and maintain welding equipment • Set up welding equipment • Adjust the welder to "tune" for proper electrode stickout, voltage, polarity, flow rate, and wire-feed speed required for the material being welded • Store, handle, and install high-pressure gas cylinders • Determine work clamp (ground) location and attach • Use the proper angle of the gun to the joint and the direction of the gun travel for the type of weld being made in the flat, horizontal, vertical, and overhead positions
1 & 2	1.4 & 2.5	1.4.9/2.5.9–1.4.11/2.5.11 Prepare a vehicle for welding and cutting operations • Protect adjacent panels, glass, vehicle interior, etc., from welding and cutting operations • Protect computers and other electronic control modules during welding procedures • Clean and prepare the metal for welding; fit, align, and clamp as required
1 & 2	1.4 & 2.5	1.4.12/2.5.12 & 1.4.13/2.5.13 Determine joint type and type of weld for each specific welding operation • Determine the joint type (reinforced-butt, lap, etc.) for weld being made • Determine the type of weld (continuous, reinforced-butt, plug, etc.) for each specific welding operation
1 & 2	1.4 & 2.5	1.4.15/2.5.15 Perform destructive tests on each weld type
1 & 2	1.4 & 2.5	1.4.16/2.5.16 & 1.4.17/2.5.17 Identify causes of welding problems, and make necessary adjustments • Identify the causes of spits and sputters, burn through, lack of penetration, porosity, incomplete fusion, excessive spatter, distortion, and waviness of bead; make necessary adjustments Identify cause of contact tip burn-back and failure of wire to feed; make necessary adjustments
3	3.1	3.1.29 Measure vehicle ride height, and determine needed repairs
3	3.1	3.1.32 Inspect and replace steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels

Units	Subunits	Competencies
3	3.1	3.1.38/3.1.39 Correct front and rear wheel camber problems on adjustable and non-adjustable suspension systems • Adjust front and rear wheel camber on suspension systems with camber adjustments • Check front and rear wheel camber on adjustable and non-adjustable suspension systems; determine needed repairs
3	3.1	3.1.40/3.1.41 Correct caster problems on adjustable and non-adjustable suspension systems • Adjust caster on suspension systems with caster adjustments • Check caster on adjustable and non-adjustable suspension systems; determine needed repairs
3	3.1	3.1.42/3.1.43/3.1.46 Check front and rear wheel toe, determine needed adjustments or repairs, and center steering wheel • Check and adjust front wheel toe; determine needed repairs • Center steering wheel • Check rear wheel toe; determine needed adjustments or repairs
3	3.1	3.1.44 Identify toe-out-on-turns (turning radius) problems, and determine needed repairs
3	3.1	3.1.45 Identify SAI problems, and determine needed repairs
3	3.1	3.1.47 Identify thrust angle problems, and determine needed repairs
3	3.1	3.1.48 Check for front wheel setback, and determine needed repairs
3	3.1	3.1.49/3.1.50 Inspect and diagnose tires, and determine needed adjustments and repairs • Diagnose tire wear patterns; determine needed repairs • Inspect tires; identify direction of rotation; check and adjust air pressure
3	3.1	3.1.52 Measure wheel, tire, axle, and hub runout, and determine needed repairs
3	3.1	3.1.53 Diagnose tire pull (lead) problems, and determine corrective actions
3	3.1/3.3	3.1.54/3.3.7 Reinstall wheels and torque lug nuts

Units	Subunits	Competencies
3	3.2	3.2.1/3.2.2 Check voltage, resistance, and amperage in electrical wiring circuits and components using a DMM • Check voltages in electrical wiring circuits using a DVOM (digital volt ohmmeter) • Check continuity and resistance in electrical wiring circuits and components with a DVOM (digital volt ohmmeter)
3	3.2	3.2.3/3.2.4 Inspect, test, and replace fusible links, circuit breakers, and fuses • Using a DVOM (digital volt ohmmeter), repair electrical circuits, wiring, and connectors • Inspect, test, and replace fusible links, circuit breakers, and fuses
3	3.2	3.2.5/3.2.8 Perform a battery state-of-charge test and slow/fast battery charge • Perform battery state-of-charge test; determine needed service • Perform slow/fast battery charge
3	3.2	3.2.6 Inspect, clean, and replace a battery
3	3.2	3.2.10 Inspect, clean, and repair or replace battery cables, connectors, and clamps
3	3.2	3.2.11 Inspect the alignment of generator (alternator) drive belts, pulleys, and fans; and adjust or replace them as needed
3	3.2	3.2.13/3.2.14 Replace vehicle lamps/lights and check their operation, and inspect, replace, and aim head lamp/light bulbs • Remove and replace head lamp/light, parking/tail lamp/light, stop lamp/light, flashers, turn-signals, and backup lamp/light; check operation • Inspect, replace, and aim head lamp/light bulbs
3	3.2	3.2.19/3.2.20 Check the operation of the windshield wiper/washer system, power side windows, and power tailgate window • Check operation of windshield wiper/washer system • Check operation of power side windows and power tailgate window
3	3.3	3.3.4/3.3.5 Bleed, flush, and pressure-test a brake hydraulic system, and determine needed repairs • Bleed (manual, pressure, vacuum, or surge) and/or flush hydraulic brake system • Pressure-test brake hydraulic system; determine needed repairs

Units	Subunits	Competencies
3	3.3	3.3.8 Remove and reinstall a caliper assembly
3	3.3	3.3.10 Check parking brake system operation
3	3.9	3.9.1 Inspect, remove, and replace seatbelt and shoulder harness assembly and components
3	3.10	3.10.1/3.10.4 Disarm SRS and verify that system is operational • Disarm SRS • Verify that SRS is operational
4	4.1	4.1.1/4.1.2/4.1.9 Identify type of plastic and repair procedure, clean and prepare surface, repair thermoplastics, and prepare repaired area for refinishing • Identify the types of plastics to be repaired • Identify the types of plastics repair procedures; clean and prepare the surface of plastic parts • Prepare repaired areas for refinishing
4	4.1	4.1.4/4.1.5/4.1.9 Repair holes, cuts, gouges, etc., in thermoset plastic parts; and prepare repaired area for refinishing • Repair plastic parts with urethane or epoxy adhesives; use reinforcements if necessary • Repair holes and cuts in rigid and flexible plastic parts using backing materials and adhesives • Prepare repaired areas for refinishing
5/6	5.1	5.1.1/5.1.2/6.4 Maintain a safe work environment • Identify and take necessary precautions with hazardous operations and materials according to federal, state, and local regulations • Identify personal health and safety hazards according to OSHA guidelines and "Right to Know" Act • Maintain safe work environment
5	5.1/5.3	5.1.3/5.3.1 Inspect, clean, and determine condition of spray guns and related equipment • Inspect spray environment for cleanliness and safety hazards • Inspect, clean, and determine condition of spray guns and related equipment (air hoses, regulators, air lines, air source, and spray environment)

16

Units	Subunits	Competencies
5/6	5.1	5.1.4/5.1.5/5.1.6/6.1 Utilize personal safety apparel and equipment • Select and use the NIOSH-approved personal sanding respirator; inspect condition and ensure fit and operation; perform proper maintenance • Select and use the NIOSH-approved (Fresh Air Make-up System) personal painting/refinishing respirator system • Select and use the proper personal safety equipment for painting/refinishing and sanding (gloves, suits, hoods, eye and ear protection, etc.) • Utilize personal safety equipment
5	5.2	5.2.1 Remove, store, and replace exterior trim and molding
5	5.2	5.2.2/5.2.3 Clean vehicle surface; identify substrate, type of finish, and surface condition; and develop a plan for refinishing using a total product system • Remove dirt, road grime, and wax or protective coatings from the area to be refinished and adjacent vehicle surfaces; wash entire vehicle • Inspect and identify substrate, type of finish, and surface condition; develop a plan for refinishing using a total product system
5	5.2	5.2.5/5.2.6/5.2.12 Dry- or wet-sand and featheredge areas being refinished • Dry or wet sand areas to be refinished • Featheredge broken areas to be refinished • Dry or wet sand area to which primer-surfacer has been applied
5	5.2	5.2.7/5.2.8/5.2.10 Apply metal treatment or primer, protect trim and adjacent areas, and apply primer to repair area • Apply suitable metal treatment or primer • Mask trim and protect other areas that will not be refinished • Spray primer onto surface of repaired area
5	5.2	5.2.11/5.2.13 Apply two-component finishing filler to minor surface imperfections, and dry-sand area • Apply two-component finishing filler to minor surface imperfections • Dry sand area to which two-component finishing filler has been applied

Units	Subunits	Competencies
5	5.2	5.2.14–5.2.16 Dust, clean, and tack off repair area • Remove dust from area to be refinished, including cracks or moldings of adjacent areas • Clean area to be refinished using a final cleaning solution • Remove, with a tack rag, any dust or lint particles from the area to be refinished
5	5.2	5.2.17/5.2.18 Apply sealer and remove any nibs or imperfections by scuff-sanding • Apply suitable sealer to the area being refinished when sealing is needed or desirable • Scuff sand to remove nibs or imperfections from a sealer
5	5.2	5.2.21 Prepare adjacent panels for blending
5	5.3	5.3.3 Check and adjust operation of HVLP spray guns
5	5.3	5.3.4 Set up, adjust, and test a spray gun using fluid, air, and pattern control valves
5	5.4	5.4.1 Determine type and color of paint already on vehicle using manufacturer's vehicle information label
5	5.4	5.4.3 Use spray technique appropriate for finish being applied
5	5.4	5.4.4 Apply selected product on a test and let-down panel, and check for color match
5	5.4	5.4.5 Apply a single-stage topcoat for refinishing
5	5.4	5.4.6 Apply basecoat/clearcoat for spot and panel blending or overall refinishing
5	5.4	5.4.7 Color-sand, buff, and polish finishes
5	5.4	5.4.8/5.4.9 Refinish rigid, semi-rigid, or flexible plastic parts • Identify the types of rigid, semi-rigid, or flexible plastic parts to be refinished; determine the materials, preparation, and refinishing procedures • Refinish rigid, semi-rigid, or flexible plastic parts
5	5.5	5.5.19 Identify dirt in the paint surface, determine the cause(s), and correct the condition

Units	Subunits	Competencies
5	5.5	5.5.27 Identify and correct buffing-related imperfections
5	5.5	5.5.29 Measure mil thickness
5	5.6	5.6.2–5.6.5 Perform final detailing • Buff and polish finish as required • Clean interior, exterior, and glass • Clean body openings (door jambs, edges, etc.) • Remove overspray
5/6	5.1	5.1.4/5.1.5/5.1.6/6.1 Utilize personal safety apparel and equipment • Select and use the NIOSH-approved personal sanding respirator; inspect condition and ensure fit and operation; perform proper maintenance • Select and use the NIOSH-approved (Fresh Air Make-up System) personal painting/refinishing respirator system • Select and use the proper personal safety equipment for painting/refinishing and sanding (gloves, suits, hoods, eye and ear protection, etc.) • Utilize personal safety equipment
6		6.2 Demonstrate knowledge of how to respond to fire situations
6		6.3 Demonstrate general safety practices
5/6	5.1	5.1.1/5.1.2/6.4 Maintain a safe work environment • Identify and take necessary precautions with hazardous operations and materials according to federal, state, and local regulations • Identify personal health and safety hazards according to OSHA guidelines and "Right to Know" Act • Maintain safe work environment
6		6.5 Access needed information
6		6.6 Demonstrate use of basic measuring tools
6		6.7 Perform basic mechanical skills
6		6.8 Manage customer relations

Units	Subunits	Competencies
6		6.9 Prepare an estimate
6		6.10 Acquire parts

Overview

This guide is designed to help you, as a teacher in an Auto Collision Technician program, to teach the critical competencies of the program. The guide does not cover ***all*** the content of the program. Local conditions within the district and the employment community will determine the full program content. It is hoped, however, that the structure of the Competency Development Guides (CDGs) in this document will provide you with a model you can use in developing the additional lesson guides you need for your particular program.

Additional teacher-made plans and handouts, related articles, etc., can all be added to this binder. Ultimately, we hope, it will provide you with an instructional guide that is truly ***yours***—one that closely fits your program's structure and your instructional needs.

What Is Covered

The "critical" competencies covered in the guide are the *High Priority–Individual* (HP–I) competencies in the Occupational Competency Analysis Profile (OCAP) for *Auto Collision Technician*. HP-I competencies are those that require students to demonstrate hands-on competency to the instructor on an individual (one-to-one) basis.

The technical competencies in the first five units of the OCAP come directly from the 1996 *ASE Program Certification Standards for Collision Repair & Refinish Technician Training Programs*. These units cover the following areas:

Unit	Instructional Focus	# of HP–I Competencies
1	Structural Analysis & Damage Repair	23
2	Non-Structural Analysis & Damage Repair	40
3	Mechanical & Electrical Components	39
4	Plastics & Adhesives	5
5	Painting & Refinishing	41

The technical competencies in the final unit of the OCAP were identified by a panel of expert auto collision technicians as important to the success of entry-level auto collision technicians in Chio. This unit covers the following area:

Unit	Instructional Focus	# of Competencies*
6	Basic Shop & Safety Practices	3 (HP-I) +7 (HP-G)

* Because safety is probably the most critical area for students to master, both High Priority–Individual and High Priority–Group competencies are included for Unit 6.

These competencies tell ***what*** critical skills should be taught.

Program Organization

The next question is ***when***—and in what order—these units and competencies should be taught. The following chart shows one logical approach for organizing the Auto Collision Technician program. The exact way in which your program is organized will, however, depend on your local situation (number of teachers in program, availability of equipment, opportunity for teachers in other specialties such as welding and electronics to teach parts of the program, etc.).

Unit	Instructional Focus	Teaching Time*
6	Basic Shop & Safety Practices	Junior Year
2	Non-Structural Analysis & Damage Repair	Junior Year
5	Painting & Refinishing	Junior Year
1	Structural Analysis & Damage Repair	Senior Year
3	Mechanical & Electrical Components	Senior Year
4	Plastics & Adhesives	Senior Year

* Once introduced, competencies should be ***reinforced*** throughout the remainder of the two-year curriculum.

It is recommended that the majority of instruction should be presented from simple to complex. However, there are times when you must take advantage of a teachable moment. If during a troubleshooting process, for example, an unrelated problem is noted and there is high student interest in that problem, it may make sense to address the unrelated problem at that time. On-the-job training is a valuable tool in the collision repair industry.

Using the Competency Development Guides (CDGs)

The CDGs in this guide are designed to provide suggestions for ***how*** to teach the units and competencies. Each CDG covers one competency (or two or more related competencies) and includes the following information:

- ***Unit, subunit, and competency number and title***—These statements come directly from the ASE-based Occupational Competency Analysis Profile (OCAP) for *Auto Collision Technician.*
- ***Objective***—Identifies the skill to be performed for evaluation, the conditions under which the skill is to be performed, and the criteria for evaluating competence.
- ***Introduction***—Provides suggestions for ways to motivate students and spark their interest in learning the competency.
- ***References***—Suggests resources that could be used to support the lesson (e.g., technical service bulletins, preventive maintenance guides, written text materials, and/or audiovisual technical information).
- ***Presentation***—Outlines content to be covered related to the competency, including key points that need to be emphasized and ideas for related academic instruction.
- ***Review questions***—Provides sample questions that can be used to provoke student thought and help you determine whether students understand the information presented.

- ***Application***—Suggests activities in which students can apply the knowledge and practice the skills learned in the lesson. Ideally, these activities require critical thinking, decision making, and problem solving and prepare students for final instructor evaluation.
- ***Evaluation***—Provides standard directions for instructor assessment using the Performance Checklist that follows each CDG.

Notice that the above description keeps saying "suggests." These lessons are not set in stone. They are designed to outline for instructors (particularly new instructors) what must be covered and to give some suggestions of how to teach that content in a motivational way, with a high level of student involvement. But the good teacher will add to these plans based on a number of factors:

- Needs, interests, and abilities of the students
- Specific tools and equipment used in the program
- His/her own personal teaching style

For example, although the practice activities included in each CDG were designed to fit the lesson content, other activities could fit the content just as well. In "Activity Options," pp. 26–29, you will find examples of the different types of activities. Feel free to make use of any of these activities in any lesson. Simply modify the activity to fit the lesson content. Likewise, feel free to develop your own practice activities.

Each CDG is generic—it talks about skills in general, without reference to particular equipment or models of cars. To add specificity to the plan, you can develop a procedure sheet (or lab guide) for each competency, using the CDG as a guide. This sheet—also designed for student use during practice—would fit the specific equipment, tools, materials, and supplies used in your learning laboratory.

Program/Instructor Resources

Advisory Committee

Each program needs to maintain a functioning advisory (or craft) committee made up of individuals from the local area who are current with the technology and who maintain ASE certification. The committee membership may include former graduates, manufacturer's representatives, collision repair & refinish technicians, service managers/service directors, supervisory personnel, or others who are genuinely interested in helping to build and maintain a successful Auto Collision Technician program.

This committee's role is to act in an advisory capacity, assisting with development of the instructional program, providing on-the-job experiences, and sharing expertise in specialized techniques and information regarding new products or procedures used in the industry.

Sources of Materials and Equipment

Each school needs to provide sufficient fiscal resources to support an up-to-date program. However, program resources can be enhanced via outside support and donations, particularly with the assistance of advisory committee members. For example:

- Complimentary or loaner copies of educational videos can be obtained from local vehicle dealers, parts houses, and the Bureau of Worker's Compensation video library.
- Retail collision repair facilities, car dealers, salvage yards, and parts houses may be glad to contribute worn or damaged parts (e.g., air bag, suspension parts, sheet metal parts, tires).
- Members of the public sometimes donate cars with salvageable parts to the school for tax purposes. (Cautions: Make sure the title is free and clear, with no liens. Have the car's owner estimate the car's value and file the form with the IRS so responsibility for the estimate is theirs, not yours.)
- Vehicle donations and other forms of support can also come from building good relationships with individual car manufacturers or dealers—or, even better with a Dealer's Association or Automotive Service Association, with links to many firms and agencies.
- When community college automotive programs get new equipment, they may be willing to donate their older equipment to the secondary school programs that send them students.

Program support can also be enhanced by applying for state funds (e.g., mini-grants, matching funds).

Sources of Technical Assistance

It is important to build and maintain an up-to-date list of addresses/phone numbers of manufacturer's representatives and others who can provide technical assistance, technical bulletin updates, continuing education information, and other information needed to maintain an exemplary program.

At one time, this address list would contain only post office addresses, but today it should also include URLs: the addresses of Websites on the Internet. A search of the Internet for manufacturers of products used in the collision repair industry could yield much useful information. Potentially useful Websites have also been created by corporations, foundations, associations, publishers, individuals, and other entities focusing on automotive information. A few examples follow.

The National Automotive Technicians Education Foundation (NATEF) has a Website where you can locate (and download) the collision repair & refinish program standards or related applied academics, get information on what's new, check out career information and upcoming events, or locate ASE-certified programs (and contact people) around the country.

NATEF
13505 Dulles Technology Drive, Suite 2
Herndon, VA 20171-3421

Phone: 703-713-0100
Fax: 703-713-3919
Website: www.natef.org

The I-CAR (Inter-Industry Conference on Auto Collision Repair) Website includes information about VICA Team USA, industry updates, and I-CAR training available. The site also houses a Collision Repair Instructors Network (CRIN) designed to enable members to stay up-to-date on the newest technology, teaching techniques, and recruitment and retention methods.

I-CAR Volunteer, Instructor & Customer Support Centre 3701 Algonquin Road, Suite 400 Rolling Meadows, IL 60008-3150	Toll-Free: 800-422-7872 Fax: 800-590-1215 Website: www.i-car.com

Collision Services Autobody Online describes itself as a one-stop resource of reliable, unbiased, regularly updated information for collision repair specialists. It includes discussion and chat groups, parts and shop finders, and a calendar of events of interest to collision repair specialists. There's access to the *Autobody Online Newsletter* and an online edition of *Automotive Body Repair News*, with past collision industry news clips and feature stories available in library archives that are searchable by key word or date. Extensive links to industries of interest to those in the collision industry are provided, and there is an online trade show highlighting new products and linking users to information from product manufacturers. Links to health, safety and environmental sites (EPA, OSHA, NHTSA, MSDSs, etc.) are also provided

Collision Services Autobody Online	Website: www.autobodyonline.com

Autobody Pro is another starting point for collision repair information on the web, with links to numerous Websites of interest: product manufacturers, service providers, jobber stores, collision repair shops, professional associations, business management sites, insurance-related Websites, financial management articles, and automotive publications on the Web. Information on safety, the environment, and MSDSs is available, as is access to industry news and the *Pro Reporter Newsletter* and its archives. A dictionary of paint terms is also provided.

Autobody Pro	Website: www.autobodypro.com

Auto Restorer On-Line, too, has links to parts houses, tools, supplies, and other items to meet the user's auto restoration and car repair needs. The site also provides an Auto Restoration Chat Room and an online forum for asking questions and sharing tips. Articles on all aspects of auto restoration—submitted by visitors to the site—are archived at the site. One unique feature of this site is a collection of restoration projects—both completed and in process. Visitors can add their projects to the gallery.

Auto Restorer On-Line	Website: www.autorestorer.com

The BodyShop Business SourceBook (Babcox Publications) provides an alphabetical listing that highlights companies offering products and services specifically designed for this industry. Each company description includes address, phone and fax numbers, and list of products offered.

BodyShop Business SourceBook	Website: www.bodyshopbusiness.com/bsbsbbod.htm

Extensive links to automotive-related sites can also be found on the following Webpages:

WOLO Automotive Links	Website: www.wolo-mfg.com/link.htm
R. C. Automotive & Industry Links	Website: www.palomar.edu/Documentation/autobody/links.html#rep

You can also use the Internet search engines to locate online product information from the specific manufacturers you prefer. For example, instructors involved in the development of this guide mentioned the following manufacturers, each of which has a site on the Web with extensive product information. Many of these sites provide more than just a product catalog, however. As a service to site users, they may provide online clinics, general fact sheets, glossaries of terms, e-mail newsletters, e-mail addresses where you can ask questions about products, and links to other related sites. Meguiar's even has a Fun Zone with a word search puzzle, crossword puzzle, and word scramble, all using automotive and surface-care terms.

3M Automotive Car Care Products Toll-free: 800-364-3577	www.mmm.com/market/automotive
DuPont Toll-free: 800-441-7515	www.dupont.com
Mattson Spray Equipment Toll-free: 800-877-4857	www.mattsonspray.com
Meguiar's	www.meguiars.com
PPG Industries, Inc. Phone: 412-434-3131	www.ppg.com
Snap-on Incorporated Toll-free: 800-866-5748	www.snapon.com

MOTOR Magazine—a source of automotive service and repair information—is available online, with a searchable database of articles and features from the print version of the magazine. The site also provides an On-Line Source Guide that lets you search directories of products & suppliers, manufacturers, technical hotlines for professional mechanics, program jobbers, and training classes and materials.

MOTOR Magazine On-line	Website: www.motor.com/magazine.htm

Delmar Publishers—a major publisher of automotive education resources for students, instructors, and professionals—has a Website called autoed.com. In addition to detailed information about available publications, the site offers an Instructor Discussion Forum where instructors can post comments and access relevant auto industry news items for discussion. The site also offers numerous links to other relevant sites, including links to specific auto manufacturers (American, European, Japanese/Korean) and sites providing auto technology and repair information.

Delmar Publishers 3 Columbia Circle Albany, NY 12203-6375	Toll-free: 800-865-5840 Website: www.autoed.com E-mail: info@delmar.com

ALLDATA Corporation's Website includes a Professional Site that offers free services to all automotive repair professionals who register.

ALLDATA Corporation 9412 Big Horn Boulevard Elk Grove, CA 95758-1101	Phone: 916-684-5200 Toll-Free: 800-829-8727 Fax: 916-684-5225 Website: www.alldata.com

The International Automotive Technicians' Network (IATN) includes professional automotive technicians from around the world, and IATN's Website provides a forum for members to exchange technical knowledge and information through discussion groups and live conferences. Any Professional Automotive Technician with a minimum of 4 years of full-time work experience is eligible to join. Teachers in Ohio who belong to IATN indicate that this is an excellent forum for getting help or answers to questions when needed—with a very short turnaround time.

IATN	Website: www.iatn.net

The Automotive Parts & Accessories Association (APAA) has a Website for members and visitors that includes, for example, illustrated information from ACDelco on automotive battery technology, which could be printed and used as a classroom handout.

APAA 4600 East-West Highway Bethesda, MD 20814	Phone: 301-654-6664 Fax: 301-654-3299 Website: www.apaa.org E-mail: APAA@apaa.com

The Carpoint Website includes an easy-to-use survey instrument you can use to get the *Kelley Blue Book* suggested trade-in value for any car.

Carpoint	Website: carpoint.msn.com

The National Transportation Safety Board (NTSB) is one excellent source of traffic safety information.

NTSB 490 L'Enfant Plaza, SW Washington, DC 20594-0003	Phone: 202-314-6000 Website: www.ntsb.gov

Another such source is the National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT). Their Website includes vehicle and equipment information (including extensive information on air bags), traffic safety/occupant issues, a variety of databases (e.g., data on recalls), technical service bulletins, regulations and standards, and information about the DOT Auto Safety Hotline. Check the Website to locate the NHTSA office serving your region.

NHTSA/DOT	Auto Safety Hotline: 888-327-4236 Website: www.nhtsa.dot.gov

Safety-related information can also be found at the U.S. Environmental Protection Agency (EPA) Website, which includes information about the science of ozone depletion, regulations in the U.S. designed to protect the ozone layer, how car and truck A/C affects the ozone layer, new refrigerants, and fact sheets.

EPA	Ozone Protection Hotline: 800-296-1996 Website: www.epa.gov/ozone/index.html

Occupational Safety and Health Administration (OSHA) news releases and regulations related to autobody repair and refinishing are available at OSHA's Website.

OSHA	Website: www.osha.gov

The GreenLink Website—a service of the Coordinating Committee for Automotive Repair (CCAR)—focuses on environmental protection issues and includes a detailed Auto-service Repair and Autobody Environmental Checklist. There is also a "virtual shop" where you can look up various environmental requirements by clicking on icons in the picture.

CCAR-GreenLink	Website: www.ccar-greenlink.org

Professional journals are a source of up-to-date instructional ideas for teachers in Auto Collision Technician programs. Consider subscribing to journals such as the following—or periodically reviewing their contents online:

Journal	Website
Midwest Autobody News	www.mwabnews.com
Autobody News	www.autobodynet.com
Automotive Body Repair News	www.abrn.com
Collision Repair Industry INSIGHT	www.collision-insight.com
Journal of Industrial Teacher Education	scholar.lib.vt.edu/ejournals/JITE/jite.html
Journal of Technology Education	scholar.lib.vt.edu/ejournals/JTE/jte.html
Journal of Vocational and Technical Education	scholar.lib.vt.edu/ejournals/JVTE/jvte.html
The Journal of Technology Studies	scholar.lib.vt.edu/ejournals/JTS

Other sources you might consider are *Dupont Refinisher News* (DuPont, P.O. Box 80021, BMP 21-2156, Wilmington, DE 19880-0021; phone 302-992-5967) and *Body Shop Business* (Babcox Publications, 11 S. Forge Street, Akron, OH 44304-1398; phone 330-535-6117).

Program Basics

Safety

Safety instruction should be provided, reinforced, and evaluated regularly throughout the two-year program. Instruction provided and evaluation results should be carefully documented and maintained for future reference.

All students should receive first-aid training, as well as instruction regarding how to respond to injury situations in accordance with the school's established procedures. CPR training (available through the local Red Cross or other recognized provider) is recommended.

Student medical forms ***must*** be obtained and taken to ***all*** off-campus activities. School policy regarding safety issues must be followed at all times.

To comply with the Occupational Safety and Health Administration (OSHA) Right-to-Know Law, you should provide each student with information regarding the potential hazards of any chemicals with which he or she may come in contact in the learning laboratory and/or collision repair facility. You must also follow local, state, and federal regulations in regard to buying, handling, and storing any hazardous products used in the laboratory or classroom. A material safety data sheet (MSDS) must be kept on file for each item requiring documentation.

Tools and Equipment

Lists of the hand tools, general lab/shop equipment, and specialty tools and equipment recommended for the support of instruction are provided in *ASE Program Certification Standards for Collision Repair & Refinish Technician Training Programs*. It is recommended that each program comply with these lists insofar as possible—adding equipment as needed, depending upon local needs, equipment availability, and the number of students enrolled in the class.

Instruction related to equipment and tools must address the following programmatic issues:

1. ***Safety***—Equipment and tools must have all shields, guards, and other safety devices in place and be operable.
2. ***Type and quality***—The tools and equipment used in a certified program must be of the type and quality found in industry. They must also be adequate and in sufficient quantity to meet the program goals and student performance objectives.
3. ***Consumable supplies***—Supplies should be available in sufficient quantities to assure continuous instruction.
4. ***Maintenance***—A preventive maintenance schedule should be used to minimize equipment downtime.
5. ***Replacement***—A systematic schedule for replacement should be used to maintain up-to-date tools and equipment in accordance with industry and safety standards. Information gained from student program evaluations, as well as advisory committee input, should be used to guide the replacement process.
6. ***Inventory***—An inventory system should be used to account for tools, equipment, parts, and supplies.
7. ***Parts purchasing***—A systematic parts purchasing system should be used from work order to supplier.
8. ***Hand tools***—Each student should be encouraged to purchase a hand tool set during the period of instruction.
9. **Storage**—Adequate storage for tools—including space for storage of the students' hand tools—should be provided. A locked tool crib, individual student lockers, and locks on students' tool kits will help ensure security.

It is recommended that from the beginning of the program, students be made aware that for performance in the learning situation, ***quality*** is more important than ***quantity***. You need to emphasize continuously the importance of quality control and materials management. Students must learn to conserve—not waste—materials. This is a very important issue with employers as well as customers.

References

Having a wide variety of references available for everyone's use in the classroom and lab will help prepare students to locate the information they need using references on the job. References you might wish to consider—either as single copies or classroom sets—include the following. Many of these references are designed specifically for use in the preparation for ASE certification. Note that ASE requires that its certified programs use text/informational materials that carry a copyright date no more than 5 years old.

Delmar Publishers
3 Columbia Circle
Albany, NY 12203-6375

Toll-free: 800-865-5840
Website: www.autoed.com
E-mail: info@delmar.com

Autobody Repair Texts

- *Motor Auto Body Repair*, 3rd ed., by Robert Scharff & James E. Duffy (1997)
- *I-CAR Professional Automotive Collision Repair* by James E. Duffy (1996)
- *Estimating for Collision Repair* by Michael Crandell (1996)

Automotive Collision Repair Video Series by James E. Duffy (1997–98)

- *Safety*
- *Body Shop Power Tools and Equipment*
- *Vehicle Construction*
- *Metal Straightening Fundamentals*
- *Body Shop Materials, Fasteners*
- *Replacing Structural Parts and Corrosion Protection*
- *Measuring Vehicle Damage*
- *Paint Preparation, Masking*
- *Painting Fundamentals*
- *Color Matching*
- *Fiberglass & Plastic Repair*
- *Unibody Straightening*
- *Estimating Repair Costs*
- *Painting Problems, Buffing & Detailing*
- *Doors, Glass, Interior Service*

Selected Other Texts

- *Delmar's Automotive Dictionary* by David W. South & Boyce H. Dwiggins (1996)
- *Basic Automotive Service and Systems* by Jay Webster (1995)
- *Motor Automotive Technology*, 3rd ed., by Anthony Schwaller (1999)
- *Automotive Computer Systems* by Donald Knowles (1996)
- *Automotive Electricity & Electronics*, 2nd ed., by Barry Hollembeak & Jack Erjavec (1997)
- *Automotive Electricity and Electronics*, 3rd ed., by Al Santini (1997)

I-CAR 3701 Algonquin Road, Suite 400 Rolling Meadows, IL 60008-3150	Toll-Free: 888-722-3787, ext. 283 Website: www.i-car.com

Instructor/Program Administrator Materials

- *Handbook: How to Establish and Operate a Successful Collision Repair Training Program*
- *Props for Collision Repair Training*
- *Smart Jobs/Smart People Speakers Kit*
- *Youth Apprenticeship: A Partnership That Truly Works*

Advance-Tech Curriculum

- *Non-Structural Repair*
- *Structural Repair*
- *Welding & Cutting*
- *Refinishing*
- *Estimating*
- *Plastic Repair*
- *Mechanical & Electrical*
- *People Actively Creating Employability (PACE)*—Student achievement program

Goodheart-Willcox Publisher 18604 West Creek Drive Tinley Park, IL 60477-6243	Toll-Free: 800-323-0440 Fax: 888-409-3900

- *Auto Body Repairing and Refinishing* by William K. Toboldt & Terry L. Richardson (1993)
- *Auto Fundamentals* by Martin W. Stockel, Martin T. Stockel & Chris Johanson (1996)
- *Automotive Encyclopedia* by William K. Toboldt, Larry Johnson & W. Scott Gauthier (1995)

Instructional Materials Laboratory 8 London Hall University of Missouri–Columbia Columbia, MO 65211-2230	Toll-Free: 800-669-2465 Website: www.iml.coe.missouri.edu E-mail: iml@tiger.coe.missouri.edu

Auto Collision Curriculum Guide

- Module 1: *Introduction to Auto Collision* (1997)
- Module 2: *Welding* (1997)
- Module 3: *Panel Repairs* (1997)
- Module 4: *Paint & Refinishing* (1997)
- Module 5: *Exterior & Interior Trim* (1997)
- Module 6: *Mechanical Services*
- Module 7: *Frame & Unibody Construction & Repair*
- Module 8: *Steering & Suspension Systems*
- Module 9: *Detailing*

Auto Collision Materials for Special Populations

- Auto Detailing (1996)
- Auto Body Repair Supplementary Units for Special Needs (1990)
- Auto Body Vocabulary Modules for Special Needs (1981)

Curriculum & Instructional Materials Center Oklahoma Department of Vocational & Technical Education 1500 West Seventh Avenue Stillwater, OK 74074-4364	Toll-Free: 800-654-4502 Fax: 405-743-5154 Website: www.okvotech.org/cimc

Auto Collision Repair Series

- *Non-Structural Repair*
- *Structural Repair*
- *Welding*
- *Refinishing*
- *Estimating*
- *Plastic Repair*
- *Mechanical & Electrical Repair*

MOTOR Information Systems	Website: www.motor.com

Collision Estimating Products

- Crash Estimating Guides
- Collision Repair Data "Frame Books"

Mechanical Repair Estimating Products

- Labor Guide
- Parts & Time Guides
- Mechanical Repair Manuals

Other Selected Products

- Technical Service Bulletin Manuals
- Wiring Diagram Manuals
- Component Locator Manuals
- MOTOR Magazine

Mitchell Repair Information Co. 9889 Willow Creek Road San Diego, CA 92131-1168	Phone: 619-549-7809 Toll-Free: 888-724-6742 Fax: 619-530-8986 Website: www.mitchellrepair.com

Print Products:

- Mechanical Parts & Labor Estimating Guides
- Mechanical Labor Estimating Guide
- ASE Test Preparation Guides

Automotive Lift Institute P.O. Box 3316 Indialantic, FL 32093	Phone: 407-722-9993 Fax: 407-722-9931

- Video: "Lifting it Right: A Safety Video for Automotive Lifts"

Organization of Instruction and the Learning Laboratory

Students need ***information***, they need to observe ***demonstrations*** of the required skills, they need to ***practice***, and their mastery of the skills needs to be evaluated. How and where these elements occur will depend on the structure of your particular program. In some cases, theory, parts, and system identification will occur in related instruction in a classroom setting, while demonstrations, practice, and evaluation occur in a shop setting.

In other cases, related instruction may occur right in the shop. If that is the case, try to create a setting there that is conducive to providing related instruction. For example, you could set aside an area in the shop with chairs/desktops, a chalkboard, a library reference area, provisions for using audiovisuals, and a podium for your use.

Whatever the setting, maintaining an organized learning area is a key factor to organized learning, as well as maintenance of a safe, secure laboratory. ***Good organizational skills begin with you, the instructor***. Students will be using a variety of tools and equipment to perform a multitude of manipulative skills ranging from detailed measuring to those requiring leverage and lifting strength. Human safety will always be a key issue in the collision repair shop, and maintaining a clean, organized work area is one factor in promoting safe practices.

How do the CDGs fit into this organization? The CDGs are not ***just*** lesson plans for the related classroom or ***just*** demonstration guides for the collision repair shop; they are both. Each is designed to outline the total instruction needed for students to achieve a particular competency. How you structure the related and shop portions of your particular lessons using the CDGs will be a local decision. You could start in the classroom (or the "classroom" area of the shop) with a presentation of the key points. Later, you could provide a demonstration in the shop to prepare students to begin to practice. Or, you could present the key points in the shop as part of a more extensive demonstration lesson. A CDG might be completed in one day, or it might be broken up and covered over a longer time period. You might be teaching alone, or sharing responsibility for the related and shop portions of instruction with another teacher.

Rotation Schedules

Since equipment and the number of practice components (chassis units, operable practice vehicles, or program vehicles) are usually limited, you may need to develop rotation schedules to ensure that all students have practice time on all competencies, with access to all the tools, equipment, and parts needed. Rotation schedules are also useful in assigning cleanup and maintenance task to ensure that everyone takes a turn at each task.

The simplest way to prepare a rotation schedule is to use an assignment or duty wheel. A duty wheel for cleanup and maintenance tasks could be prepared as follows:

- Cut a large circle out of stiff paper.
- Divide the circle into pie-shaped wedges, one for each student in the class. Print one student's name in each wedge at the outside edge of the circle.
- Cut a smaller circle out of stiff paper.
- Divide the smaller circle into the same number and size of pie-shaped wedges as in the large circle.
- Decide how to assign tasks to the wedges in the smaller circle, considering (1) the number of tasks to be performed and (2) the size of the tasks to be performed.

  For example, assume that the required tasks include equipment maintenance, office cleanup, locker room cleanup, water hose handler, parts & supplies inventory, safety manager, shop manager, tool room manager, sweeper, and floor washer. That's 12 tasks, and let's assume you have a class with 16 students—***more students*** than tasks.

  In a large facility, one solution would be to divide the facility into two areas and to assign two students as sweepers and two students as floor washers for each area. Thus eight of your wedges could be filled in as follows: sweeper–area 1; sweeper–area 1; sweeper–area 2; sweeper–area 2; floor washer–area 1; floor washer–area 1; floor washer–area 2; floor washer–area 2). Since these are menial tasks, it would be best if you spread them out around the circle, alternating them with the more interesting tasks so that an individual student doesn't sweep or wash floors two weeks in a row.

  If you have ***more tasks*** than students, then smaller, easier, quicker tasks can be grouped into one wedge and performed by one student.
- Write the tasks in the wedges as planned.
- Line up the centers of the two circles, with the smaller circle on top. Punch a hole through the centers, and join the two circles using a brass fastener (available at any office supply store).
- By rotating the inner circle, you quickly and easily rotate assignments.

A duty wheel for rotating students through practice activities would be developed in a similar manner. In this case, however, instead of printing the names of individual students on the wedges, you would divide your students into groups, and print the group designations in the wedges (Group 1, Group 2, etc.). The wedges on the other circle would list the work stations for practice (e.g., straightening and aligning mash damage, sag damage, sidesway damage, twist damage).

The way in which you set up these stations to rotate through will depend on your program's organization, the class size, and available tools, equipment, and supplies. These factors will also determine how long students spend on each activity—how often activities rotate (e.g., weekly, biweekly). Whatever rotation schedule is selected, make sure that it is clearly communicated in advance to students.

In rotating practice, consider staggering the startup so that you, too, can rotate through the tasks, providing an initial demonstration for each group before they begin to practice. If an applied academics teacher is available, he or she can help supervise groups. Using more-advanced students to assist other students is also helpful—and auto collision technicians need to be able to help and support each other on the job. Once initial demonstrations have been provided, you can circulate from student to student, observing, answering questions, reteaching, and reinforcing key concepts as needed.

For additional information on how to organize instruction and the learning laboratory, you might wish to refer to a relevant professional development resource such as *Managing the Occupational Education Laboratory*, 2nd ed., by George Storm (Ann Arbor, MI: Prakken, 1993).

Individual Career Plans (ICPs) and Career Passports

Every student in Ohio should have an individual career plan (ICP). The ICP is a learning process for students that begins in the elementary years (K–5) with career information and exploration activities designed to prepare students to make educational and tentative career decisions in the middle grades.

In the middle-grade years (Grades 6–8), specific and organized activities provide the basis for students to identify and explore initial career goals and identify the educational plan needed to achieve those goals, both at the secondary level and beyond. This is the ICP document.

At the high school level, students continue to explore and verify their educational and career goals and to formally review, revise, and add to their ICP document annually.

The ICP document can include forms for students to record relevant personal information, their education history, the results of tests and assessments taken, work-based experiences, courses taken or completed, extracurricular activities, educational plans, career goals, and activities leading to those goals. A crucial component of the ICP is documentation of the employability and technical skills mastered. For students in Auto Collision Technician programs, these would be the competencies contained in Ohio's Occupational Competency Analysis Profile (OCAP) for *Auto Collision Technician*, which include both employability skills and the technical skills from the *ASE Program Certification Standards for Collision Repair & Refinish Technician Training Programs*.

Once completed, these records can be compiled into a portfolio the student can use in presenting his or her achievements and qualifications to potential employers. In Ohio, this portfolio is called the Career Passport. Just as a U.S. passport provides the documentation needed by a traveler to enter a foreign country, a Career Passport provides the documentation a student needs to enter the world of work.

Professional-quality ICP folders and inserts and Career Passport portfolios are available through the Publications Office at the Center on Education and Training for Employment. (For additional information, check the online catalog at <<www.cete.org/products>> or call 800-848-4815, ext. 2-4277; or 614-292-4277).

The Instructional Materials Laboratory at the University of Missouri–Columbia also has available a Competency Profile for documenting each student's achievement in an Auto Collision program. The sturdy cardboard tri-fold record-keeping device lists all ASE tasks and provides space for rating student achievement level on each task. Space is also provided for noting standard class management information (student's name, address, phone number, Social Security Number, when student entered program; hours absent; who to notify in case of emergency; etc.); for rating employability competencies (i.e., personal characteristics, job seeking techniques, and entrepreneurship awareness); and for documenting on-the-job training work experiences. (For information on how to contact the Missouri IML, refer to p. 14).

Individual Educational Plans (IEPs)

Many classes include students with IEPs written specifically to address individual students' special or exceptional needs. Each plan should be developed with the direct involvement of the school counselor, program instructor, and parents or guardians, who have a legal and moral responsibility to plan and monitor the educational experiences of all children so they can be prepared to be gainfully employed.

All parties must be fully aware of the student's capabilities as well as the expectations of potential local employers. It is unfair to prepare a student for employment only to find that some impairment will restrict the student from being gainfully employed upon graduation. Identify those areas of employment (perhaps in the peripheral related areas) that can be accessible to graduates who have specialized or limited skills.

All parties involved in the IEP development process should communicate regularly so that each party has a clear understanding of the IEP and how it is to be implemented. Students with IEPs should be evaluated in accordance with school policy, which will usually require varied criteria.

Assessment

Ongoing evaluation of student achievement is necessary for program accountability and to monitor student progress. A variety of informal and formal evaluation methods should be used. Informally, you can monitor student performance during instruction. Are they actively listening? Are their questions on target? Do their comments indicate understanding? In the shop, you can observe students as they practice skills and ask questions to verify their understanding. Formally, you can administer quizzes and knowledge tests and evaluate final performance and products.

Each CDG ends with a checklist for evaluating performance. The checklist criteria represent the key standards for performance on the job. If local conditions require, you may add criteria to a checklist so that it reflects more exactly what you will be looking for in a student's performance. Input from advisory committee members, along with that of other local employers, can be of great assistance to you in establishing the student performance standards expected and the evaluation criteria.

Students should be given copies of the checklist before they begin to practice so they know what criteria they are expected to meet. Ask them to use the checklists to self-evaluate. When a student thinks he or she can meet the criteria, that's the time for teacher evaluation.

In rating performance, 5 is the highest level; 1 is the lowest. To get a sense of what these levels mean, consider the following anchor ratings:

Level 1	Level 3	Level 5
Unable to complete task in timely manner	Work slightly exceeded time standards set by instructor	Work performed within time standards set by instructor
Total disregard of prescribed safety standards	Failure to comply with one or more safety standards	Full compliance with safety standards as prescribed by manufacturer/industry
Total failure to follow proper procedure(s)	Some steps in procedure missed or performed inexactly	Manufacturer's procedures followed precisely
Total failure to meet manufacturer's specifications	Work performed slightly outside manufacturer's specifications	Work performed accurately within manufacturer's specifications
Total failure to maintain clean work area/vehicle	Some standards of cleanliness missed or performed inexactly	Clean work area/vehicle maintained
Unacceptable quality of work performance	Average quality of work performance	High quality of work performance
Required considerable supervision	Required moderate supervision	Performed with minimum supervision

Your advisory committee can help you establish the anchor ratings you will use. At a meeting early in the year, members could be asked to review the anchor ratings and come to consensus on the standards, as well as the factors that should be considered in assigning a *2* or *4* rating. If they have signed off on the standards to be met, they should be more inclined to hire graduates of the program.

Following teacher evaluation, the student and teacher should meet and compare ratings. If the student's ratings vary from those of the teacher, the reasons for these variations should be addressed. Workers need to be able to accurately self-evaluate their performance on the job. A worker whose "completed" work is routinely below standard is unlikely to last long.

Students whose performance does not meet the criteria should not get a grade and move on to the next skill. You and the student should devise additional practice activities so that the student can improve where needed. His/her performance should then be reevaluated. Bear in mind that this need not involve a great deal of extra time. In many cases, the student will only need to work on part of the performance—and the second evaluation can focus only on that part. Bear in mind, too, that students should not be recycled through additional practice and reevaluation to infinity. If a student is not making reasonable progress, other steps may need to be taken.

Completed checklists can be retained to document student progress and achievement. For example, you could prepare a file folder for each student and place each completed checklist in the file—preferably in a file drawer that locks.

When a student successfully performs a skill, that skill could also be checked off on a student progress chart. Using individual student progress charts to monitor student competency achievement can be very helpful to both you and the student. The student can check the posted progress chart daily to determine which skills he or she needs to practice. Student progress charts can also be maintained on a computer that is accessible for student use.

Evaluation and grading policies will vary from school to school. Some school districts may require two grades for the vocational program (e.g., one for the related theory class and one for performance in the learning laboratory or on the job). Other schools give only one grade for the vocational program. Some schools may include individual participation in the vocational student organization, daily attendance, attitude, etc., in the final grade. You need to follow your school's established grading policies.

Additional Program Elements

Customer Service Orientation

For many people, their vehicle is a key factor in their success—it provides a means of transportation for a variety of purposes on a daily basis. It is a possession that can provide a lot of pleasure as well as a level of independence for daily living activities. When that vehicle is unavailable as a result of a collision, much frustration can result. Thus, the auto collision technician has a very important role in society. A big part of the technician's job involves dealing with the customer—either directly, or indirectly through a service manager or supervisor. Technicians need to be good listeners.

It is critical for students to realize the importance of listening to customers. Once students reach a competence level where they are working on customer-owned vehicles, it is important for students to learn to interview a customer to verify a customer's complaint. Technicians need to practice developing communications skills and learn how to interact with customers on a one-to-one basis. The information obtained during a customer interview can often provide specific detail to assist with solving a problem, troubleshooting repairs, diagnosing extent of damage, or developing the repair plan.

Professionalism and Maintenance of ASE Certification

We need to instill in students the importance of remaining current with the profession after they graduate. With the continually changing technology, continuing education is a must. ASE is recognized nationally for its outstanding professional program, making its technician certification attractive and transferable from state to state. Having vocational instructors and programs that are ASE-certified demonstrates to the community that the best educational opportunities are available to the students in the program. The ASE symbol is recognized by many people in the community. Those who have invested time and money in this certification display its symbol with pride.

Vocational Student Organization (VSO) Participation

Student participation in the vocational student organization—Vocational Industrial Clubs of America (VICA)—and in its sponsored competition and leadership activities should be encouraged. Leadership training gained within the VSO can provide valuable insight for those students who may aspire to management and/or entrepreneurial positions.

National VICA has available two major curricular products designed to support instruction and facilitate partnerships between business, industry, and education:

- *Professional Development Program* (PDP)—a school-to-work employability skills training curriculum that guides students through activities related to communications, ethics, conflict resolution, government awareness, time-management skills, career research, etc. The program enables instructors to become managers of the learning process, encourages students to become responsible for their own learning and development, and fosters the involvement of local businesses in the training of tomorrow's entry-level workers.
- *Total Quality Curriculum* (TQC)—provides a vehicle for incorporating Total Quality Management (TQM) principles into daily classroom activities. The curriculum includes an overview of the quality movement and covers such concepts as productivity growth, customers and customer satisfaction, continuous improvement, quality teams, idea generation, reaching consensus, decision making, and use of charts and diagrams.

VICA also holds one-day PDP and two-day TQC training seminars.

National VICA P.O. Box 3000 Leesburg, VA 20177-0300	Phone:	703-777-8810
	Toll-Free:	800-829-8727
	Fax:	916-684-5225
	Website:	www.vica.org

Academic/Vocational Integration

Whenever possible, you should reinforce academics in your instruction and be willing to work with the academic teachers who teach your students—coordinating instruction between the vocational and academic classes and, if possible, helping the academic teachers add an occupational context to their instruction. Each CDG provides a few suggestions for ways of involving these teachers, but you can do more. For example:

- Invite academic teachers into your classroom or shop to observe. Visit their classrooms as well.
- Invite academic teachers to be part of advisory committee meetings.
- Share materials (e.g., texts, journals, specification manuals, MSDSs, automotive dictionaries, and authentic materials used by auto collision technicians on the job), as well as leads to other sources (e.g., Website addresses).
- Develop joint lesson or project plans.

You and the academic teachers can find lists of the mathematics, science, and communications competencies that are critical to auto collision technicians by referring to two resources:

- *Applied Academic and Workplace Skills for Collision Repair & Refinish Technicians* (1995), available from NATEF (Phone: 703-713-0100; Website: www.natef.org)
- Occupational Competency Analysis Profile (OCAP) for *Auto Collision Technician* (1997), available from the Publications Office of the Center on Education and Training for Employment (Phone: 800-848-4815, ext. 2-4277; or 614-292-4277; Website: www.cete.org/products)

An additional resource that can be of great help is *Making Connections: A Curriculum Ideabook for Teachers of Applied Academics and Industrial & Engineering Systems*. This 1998 document is full of activities and strategies to help trade & industrial teachers and academic teachers integrate their curricula. It also provides lists of Internet sites and curricular resources (e.g., textbooks, workbooks) that support an integrated approach. *Making Connections* is also available from the Publications Office of the Center on Education and Training for Employment.

Please note that, although the activities suggested in the CDGs for academic coordination address primarily mathematics and science, this is not to suggest that communication skills are not critical. Rather, these skills tend to cut across all competencies:

- Auto collision technicians need strong speaking and listening skills in order to deal with customers, whether in person or on the phone. They must have good questioning skills to obtain the information they need. These skills are also needed in working with supervisors and coworkers.
- They need to be able to write up service orders and work orders and parts orders in a clear, legible, accurate way, with terminology spelled correctly.
- They are in critical need of strong abilities to use written resources (TSBs, parts manuals, service manuals, specification manuals). They must be able to locate information and interpret it, whether in text, graphic, chart, or tabular form.

Guest Speakers

Even the most conscientious teacher can't always keep up with the sometimes rapid changes in the field: new equipment, new procedures. Even the most experienced teacher is unlikely to have equal expertise in every area of the occupation. Inviting experts into the classroom as guest speakers can fill this gap—and provide instructional variety as well.

For example, representatives of tool and equipment manufacturers can be invited to discuss special products and equipment used by auto collision technicians. Specialized competencies can be discussed and demonstrated by advisory committee members, employers, representatives from manufacturers and professional organizations, and/or former graduates.

Visits by guest speakers should be ***planned*** events. Before the event, students should be given some background information about the expert and the topic of his/her presentation. They should be told what will be expected of them during and after the visit (e.g., taking notes, preparing a report). Having them develop a list of questions they want the expert to answer is also a good preparation activity. Student volunteers can take responsibility for certain activities related to the visit (e.g., meeting the guest and escorting him/her to the class location on the day of the visit; writing and sending a thank-you letter after the visit).

Field Trips

Class field trips to observe real-life work processes performed by certified collision repair & refinish technicians provide realistic learning experiences for the students. This is excellent opportunity to utilize the expertise of the advisory committee members. They may be able provide field trips to their own firms, suggest other relevant field trip sites, and/or assist in chaperoning students during a field trip.

Trips can be arranged to a manufacturer, dealership, parts center, specialty service center, auto center affiliated with a franchise operation or local retailer, or small independent collision repair facility. Trips may involve simple walk-throughs and brief presentations by various workers at the site. Or demonstrations may be presented (e.g., of new or very expensive specialty equipment not available in the school shop). Such experiences give students the opportunity to see and hear firsthand about the occupation. It is a true reality check.

Job Shadowing or Mentoring

Job shadowing means following a worker around on the job and observing the tasks performed—usually for a short time period. *Mentoring* involves pairing an experienced worker—a mentor—with a student; the mentor provides the student with information and advice. Either of these activities can enhance the learning process and provide rich opportunities for career exploration and job awareness.

It is recommended that all students—both junior and senior—be aligned with an experienced worker in the collision repair & refinish industry (perhaps a member of the advisory committee) so they can get a realistic view of what happens on the job. Providing students with the opportunity to interact with strong, successful role models can be a very important component of the training program.

These experiences need to follow a structured plan, and all school policies must be adhered to. The assignments may be teacher-arranged, or students may be responsible for making all arrangements themselves, including identifying the individual they will shadow or the mentor they will be paired with. Regardless of how the experiences are arranged, each student should be responsible for sending a letter of introduction prior to the assignment and a thank-you letter following the assignment.

Job Experiences

Job experiences come in a variety of forms. They can be called *early job placements* or *internships* or *cooperative experiences*. They may be paid or unpaid. They may be full- or part-time. They may take place before or after school. They may occur in place of school for a certain time period (e.g., second half of the senior year). Or the student might spend a half day at school and a half day on the job. What the experiences have in common is exposing the student to the reality of the workplace, with a real role in participating.

These experiences are generally quite positive and very important. The technology in the collision repair & refinish profession is changing rapidly, and employers are often happy to hire young, enthusiastic graduates who are eager to learn and who can benefit from early on-the-job training and experience.

The investment in training and the cost of specialized equipment required for a collision repair shop is sizable. The school, students, and parents must recognize that the employer's acceptance of a student into a job experience is a compliment to the school program—an honor a student must earn. Policies governing these placements must be established, and all parties must be aware of potential liability involved if the guidelines are not adhered to.

Such guidelines might include requiring that the student do the following:

- Complete all the preliminary paperwork prior to placement assignment (e.g., school forms, letters of introduction, appropriate thank-you letters).
- Earn and maintain specific grades.
- Demonstrate a positive attitude toward school and the collision repair & refinish profession.
- Demonstrate good school attendance (limited number of tardies and absences).
- Maintain above-average performance at the job placement assignment.
- Comply with all school and employer policies.
- Provide his/her own transportation to and from school and work.

In addition, ***students must have an untarnished driving record to ensure their employment.*** Once a graduate is employed, it will be necessary for the technician to be bondable so she or he can work on customer-owned vehicles and possibly test-drive the vehicle (depending on employer policies). Drug screening is also a commonplace requirement of employment these days. Students need to be made aware of these employment conditions—and to take them seriously.

Implementing job experiences is another time when the advisory committee members can be very helpful to the Auto Collision Technician program. Advisory committee members can let students know how important attendance, attitude, and mastery of program competencies are in order to qualify for these placement opportunities. Advisory members can also often provide placement positions for qualified students.

Activity Options

Each CDG provides activities requiring students to apply the skills they are learning, but you are welcome to substitute or add other activities of your own. The following are examples of the types of activities you might want to consider. Bear in mind that almost all of these activities could be carried out by students working either individually, in small teams, or as a whole class. Providing for both individual work and teamwork can make instruction more interesting—and more consistent with how work is performed in the real world.

Have students identify tools, equipment, supplies, and components; for example:

- Give students sheets with different VIN codes and paint labels, and have them interpret the codes.
- Give students teacher-developed worksheets requiring them to match symbols and letter designations with the components and wiring connections they represent.
- Give students a teacher-prepared diagram of an air bag system, and have them label the components.
- Give students a diagram of a cooling system, and have them indicate the potential trouble spots.
- Give students a specific model of air bag system, and have them diagram the circuits that can be checked.
- Have students diagram how coolant flows through a cooling system.
- Provide students with disassembled door hardware, and have them identify all parts.
- Prior to assembly, have students lay out the parts in the order in which they will go into the door.
- Have student identify types of taps and dies (e.g., size them to a thread).
- Assign students specific vehicles, and have them identify the correct type and amount of coolant for each vehicle.
- Have students set up the special tools required for strut disassembly.
- Write wrench sizes on board. See which student can get a box of wrenches to match the board order first.

Have students develop written materials to guide their performance of job tasks; for example:

- Have students develop an interview form with sample questions to ask customers and devices (e.g., checklists) to use in recording the customer's responses quickly and accurately.
- Have students develop a procedure sheet for adjusting steering components on a given vehicle (as specified by instructor) that can be used to guide student practice in the lab.
- Have students design a diagram of the lug nut tightening sequence.
- Have students develop a chart listing where wind and water leaks are heard on a vehicle (Column 1) and the possible causes for each (Column 2).
- Set up a display of worn components (tires, struts, tie rods, ball joints), and have students prepare a table, naming each condition and listing the problems each might present.

- Divide students into small groups, and assign each a particular vehicle. Have each group develop a procedure sheet on how to select and install brake fluid for the assigned vehicle, including all safety precautions. Then ask students to compare sheets and note commonalities and differences between procedures.
- Have each student develop a chart or checklist of items to look for when diagnosing wheel bearing troubles. Ask them to be specific and to place items in order of importance, with the most likely troubles first, and so on.

Involve students in role-playing and team-building activities; for example:

- Have students divide into pairs and role-play the customer interview process. For example, school personnel or students in other classes could be interviewed about vehicle problems they are experiencing or have experienced in the past.
- Divide students into small groups, and give each student in the group only one piece of diagnostic information. This will force students in the group to talk with each other and cooperate in order to identify the needed repair.
- Have students role-play instructing a customer in how to check and maintain proper inflation pressure to get the best ride and wear from the tires.
- Provide pairs of students with repair problems, and have one student role-play the shop manager and one student role-play the customer. The shop manager's task is to prepare a repair order with customer input and communicate solutions to the customer.
- Provide pairs of students with a parts catalog, and have them role-play phone contacts, with one student playing the role of parts person and one student playing the role of technician seeking parts information.

Provide students with worksheets and case studies that require them to solve problems; for example:

- Provide students with an estimating manual, typical labor jobs, and a labor rate per hour, and have them calculate labor costs.
- Give students electrical diagrams with practice problems, and have them solve them using Ohm's law.
- Give students a list of DMM readings, and have them identify possible causes for each reading.
- Give students sheets with questions to answer by locating and interpreting the labels on specific vehicles.
- Use a wiring diagram to indicate a vehicle fault (perhaps an open on a parking lamp), and have students indicate what test light and/or DMM readings they think this fault would produce. Then have students introduce the fault into the vehicle and determine the actual reading it produces.
- Give students a written case study describing a specific painting problem, and have them indicate how to correct that problem.
- Give students written case studies describing different types of fire situations, and have them select the correct type of extinguisher and correct overall response for each situation.

Involve students in research; for example:

- Have students determine what factors are involved in how the manufacturer decides what the tire pressure should be.
- Have students locate five sites on the Internet that contain service information.

- Provide students with a list of particular vehicle makes, models, years; and ask them to locate the alignment specifications for each vehicle in the appropriate manual.
- Have students locate the material safety data sheets (MSDSs) and local guidelines for the flushing solutions used in the shop and outline the proper procedure for disposing of each solution.
- Have students research the effects of contaminated refrigerant on the refrigerant handling equipment used in the shop and report on their findings.

Provide opportunities for students to use other talents (e.g., communication skills, artistic skills); for example:

- Ask students to design handouts, posters, etc., to alert customers to the effects on tires and ride if the wheel and tire assembly is not balanced correctly.
- Have students work in teams to develop safety posters, fliers, handbooks, etc., covering the use of personal safety equipment in the shop.
- Have students work in teams to create their own labels for R-12 and R-134A as if they were the manufacturer. How would they design labels that clearly and easily communicate the cautions and warnings to the user.

Provide guided practice of the whole task and/or the various smaller skills required in task performance; for example:

- With permission from local parts suppliers, allow students to call for "estimates" on vehicles they repair in the shop. Ask them to record all prices, quantities, part numbers, etc., on given repair estimate form.
- Provide students with several vehicles with varying degrees of damage, and ask them to determine (a) the extent of damage and (b) whether the panels should be repaired or replaced.
- Provide students with a variety of metals (e.g., cast iron, mild steel, aluminum, cast aluminum, high-strength steel, high-strength/low-alloy steel), and have them work individually to determine weldable/non-weldable characteristics of those metals. **Note:** Some non-metals could be included to ensure that students can differentiate between metals and non-metals. Have students compare their findings.
- Provide students with a variety of welds—some done with proper equipment angle and direction, and some done with improper angle and direction—and ask them to determine the effects of angle and direction on the quality of each weld.
- As students practice attaching anchoring devices to given vehicles, quiz them individually on the process (e.g., ask them to demonstrate how to check the clearance around fuel lines, etc.).
- Provide students with micrometers, and have them measure steel thickness when hot and when cold and describe their findings.
- Provide students with a soft metal (1/2"-thick aluminum is good). Have them select a bolt size, correct drill bit and tap to use, and then drill and tap a hole to correct size for that bolt. Finally, have them install bolt and tighten it to test the new thread's strength.
- Provide students with damaged body panels, and have them remove the paint using a variety of sanding and grinding discs. Then ask them to compare the rate of removal and depth of sand scratches left by different types of abrasives.
- Tape masking paper to the walls, and have students practice spray techniques using guns filled with water/food coloring mixture.

- Give students a teacher-painted panel as a standard, and have each student paint a test panel trying to match the standard. Then label the panels produced, and have students try to pick the one that most closely matches the standard. Have students discuss the variations between panels and identify possible causes.
- Provide students with a variety of used or donated panel assemblies, and have them identify the different types of sealers and sound deadeners that were used on them.
- Divide students into four groups. Have Group 1 properly mix filler. Have Group 2 overmix with hardener. Have Group 3 undermix with hardener. And have Group 4 fail to mix thoroughly. Have each group examine all four samples and summarize their observations.
- Provide students with a variety of scrap plastics, and have them use different products on each plastic and document the results.
- Provide students with a variety of vehicles/panels to examine, and ask them to select the appropriate primer(s) for each.
- Have pairs of students change the wheel toe and then determine the effect of the change on the turning radius.
- Have students practice performing steering operating inspections and determining needed repairs.
- Ask students to match tire rotation (cross) patterns to the correct vehicle (e.g., front-wheel drive, rear-wheel drive).
- Hold a clinic for other classes to give students a chance to practice techniques for replacing a flat tire.
- Set up stations, with each station having one used tire exhibiting wear caused by a different specific cause. Divide students into teams and have them rotate through the stations, inspecting each tire and identifying its degree of wear and wear pattern. Then have the teams compare their observations and results.
- Disable one or more vehicles, and have pairs of students work together to diagnose the cause of the electrical problem.
- Set up vehicle with headlights on and engine at 2,000 RPM, and have students use DMM to check for AC voltage at battery (max .4 volts AC).
- Have students use a digital multimeter to check voltage drop across (a) a tight terminal, (b) a loose terminal, (c) a corroded terminal, and (d) a clean terminal.
- Ask students to perform an instructor- or school-prepared safety inspection of the entire automotive laboratory.

Unit 1: Structural Analysis and Damage Repair

Subunits 1.1/1.2: Frame Inspection and Repair/Unibody Inspection, Measurement, and Repair

Competency 1.1.1: Diagnose and measure structural damage using tram and self-centering gauges according to industry specifications

Competency 1.2.2: Diagnose and analyze unibody vehicle length, height, and width using a tram gauge

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose and measure vehicle dimensions and structural damage using tram and self-centering gauges
Criteria:	In accordance with the criteria in the checklist for Competencies 1.1.1/1.2.2

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when diagnosing and measuring vehicle dimensions and structural damage using tram and self-centering gauges. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Show students examples of actual tram and self-centering gauges, copies of frame dimension manuals, and photos or other graphics showing the underside of vehicle bodies.

2. Ask students why it is important to diagnose and measure vehicle damage. Explain that accurate measurements are critical for unibody vehicles since steering and suspension are mounted to the structure, which can cause wear or handling problems.

3. Explain the importance of correctly measuring a vehicle as a basis for diagnosing damage and determining needed repairs. If measurements are inaccurate, this will cause unnecessary repairs or further damage to the vehicle.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Care and Handling of Equipment	2. Gauges and pointers are designed with 0 level of tolerance. Improper use or care of equipment may cause damage, which in turn may cause measurements to be inaccurate.
3. Using Frame Dimension Manual	3. Obtain needed vehicle information (make, model, body style, VIN). Use vehicle information to locate appropriate measurement chart in frame dimension manual. Identify manufacturer-specified measurements for the particular vehicle and manufacturer's measurement guidelines (measure hole to hole, bolt to bolt, etc.).
4. Using Self-Centering Gauges	4. Determine how/where to install gauge according to manufacturer's recommendations. Identify—and make a written note of—any measurement discrepancies.
5. Diagnosing Damage	5. Determine direction of damage (1.2.6), and analyze effect on— • frame; • body; and/or • mechanical components.

Presentation Outline	Steps to Cover/Key Points to Make
6. Using Tram Gauges and Pointers	6. Set up gauge in accordance with factory specifications. Measure vehicle, keeping gauge parallel with datum plane. *Datum plane*—imaginary plane that is horizontal to the frame or bottom of vehicle. Allows you to gain information such as height measurement. **Key Point:** Use different pointer lengths to keep tram gauge parallel with body of vehicle. Record specified and actual measurements on a measurement chart, and compare. Determine whether measurements obtained are within allowable tolerances (per manufacturer's guidelines). **Key Point:** Vehicles are factory-designed with 3mm–5mm of tolerance. If not within tolerances, make a written note of the measurement discrepancy. **Key Point:** Measure ***accurately*** and ***often***, and ***recheck*** all measurements.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover how to read a tram gauge, English and metric measures (measuring and converting), and related geometry (measuring planes, asymmetrical and symmetrical shapes and designs).

Review:

Ask students review questions such as the following:

1. What is a tram gauge, and what is it used for?
2. How does a self-centering gauge measure parallel, center, and height dimensions?
3. Define the following terms: *asymmetry, symmetry, datum plane,* and *centerlines.*
4. A car measures 128.6cm. What would this measurement be in millimeters?
5. Which measuring system—English or metric—is better to use? Explain why.

Application:

1. Provide students with an illustration of a tram gauge and accessories, and ask them to label each part/accessory by name and use.
2. Provide students with various objects, and have them measure them with a yardstick and tape measure, remeasure them with a tram gauge, and then compare the results (which was more accurate?).
3. Provide students with various vehicles, and ask them to obtain measurements using a tram gauge and self-centering devices and then to compare them to the manufacturer-specified measurements.

Evaluation:

√ The student will diagnose and measure vehicle dimensions and structural damage using tram and self-centering gauges. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.1.1/1.2.2.

Competency 1.1.1: Diagnose and measure structural damage using tram and self-centering gauges according to industry specifications

Competency 1.2.2: Diagnose and analyze unibody vehicle length, height, and width using a tram gauge

Performance Checklist

In diagnosing and measuring vehicle dimensions and structural damage using tram and self-centering gauges, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Obtained all necessary vehicle information (e.g., make, model, body style, VIN)	☐	☐	☐	☐	☐
4. Located correct measurement chart for specific vehicle	☐	☐	☐	☐	☐
5. Attached self-centering gauges according to manufacturer's recommendations	☐	☐	☐	☐	☐
6. Analyzed vehicle condition using self-centering gauges (twist, sidesway, mash, diamond, sag)	☐	☐	☐	☐	☐
7. Set up tram gauge in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Obtained accurate vehicle measurements	☐	☐	☐	☐	☐
9. Recorded measurements accurately	☐	☐	☐	☐	☐
10. Compared measurements obtained to manufacturer-specified measurements	☐	☐	☐	☐	☐
11. Noted in writing any measurement discrepancies	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 1: Structural Analysis and Damage Repair

Subunit 1.2: Unibody Inspection, Measurement, and Repair

Competency 1.2.6:	Determine the extent of the direct and indirect damage and the direction of impact; plan the methods and sequence of repair
Competency 1.2.17:	Determine the extent of damage to structural steel body panels; repair or replace

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Determine extent of damage and direction of impact, and plan repair methods/sequence
Criteria:	In accordance with the criteria in the checklist for Competencies 1.2.6/1.2.17

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when determining the extent of damage and direction of impact and planning repair methods/sequence. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Several initial steps must be completed in order to properly repair a vehicle with unibody damage to preaccident condition: the direction of impact must be determined, direct and indirect damage must be analyzed, and a repair plan must be developed.

2. Part of damage assessment involves identifying whether damaged panels should be repaired or replaced.

3. Show students pictures of vehicles with different types of unibody damage, transparencies showing direct and indirect damage, a sample organizational chart of repair planning, and copies of collision estimate guides (e.g., Mitchell, Motor).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Determining Direction of Impact	2. Talk with customer or estimator to determine direction of impact. **Key Point:** It is critical to know the direction of impact in order to properly analyze the extent of damage.
3. Identifying Direct Damage	3. Using information from customer or estimator, locate area of direct damage. Determine extent of damage by— • measuring; and/or • looking for parts that are bent, broken, and/or out of alignment.
4. Identifying Indirect Damage	4. Follow the direction of impact along related or attached components. Check for misalignment of parts (e.g., door, hood, and trunk gaps), broken seam sealer, etc.
5. Determining Extent of Panel Damage	5. Look for kinks, tears, or broken welds. If any of these conditions exist and are severe (a matter of judgment), the panel should be replaced in accordance with manufacturer's recommended procedures. If those conditions do not exist or are not severe, the panel can be repaired.

Presentation Outline	Steps to Cover/Key Points to Make
6. Writing a Repair Plan	6. Determine replacement parts needed. Determine which parts can be repaired. Identify what needs to be removed to make repairs (a time/cost factor). **Key Point:** The plan should include bulleted items as well as a sequence for how repairs should be made. **Rule of Thumb:** Last damage in, first damage out (repaired).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on metallurgy, molecular structure of metals, and principles of force.

Review:

Ask students review questions such as the following:

1. What is the difference between direct and indirect damage?
2. What rule of thumb should be followed in repairing damage?
3. What conditions could dictate whether damaged panels should be repaired or replaced?
4. Where would you find the information you need concerning the replacement method that should be used?

Application:

1. Provide students with a wrecked vehicle, and have them diagnose the vehicle damage, determine the repair method, and write a repair plan. A teacher-prepared repair plan or rubric could be provided to students to use in evaluating their work.
2. Provide students with several vehicles with varying degrees of damage, and ask them to determine (a) the extent of damage and (b) whether the panels should be repaired or replaced.

Evaluation:

√ The student will determine the extent of damage and direction of impact and plan repair methods/sequence. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.2.6/1.2.17.

Competency 1.2.6: Determine the extent of the direct and indirect damage and the direction of impact; plan the methods and sequence of repair

Competency 1.2.17: Determine the extent of damage to structural steel body panels; repair or replace

Performance Checklist

In determining the extent of damage and direction of impact and planning repair methods/sequence, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Accurately determined direction of impact	☐	☐	☐	☐	☐
4. Identified location(s) and extent of direct damage	☐	☐	☐	☐	☐
5. Identified location(s) and extent of indirect damage	☐	☐	☐	☐	☐
6. Identified panel kinks, tears, or broken welds	☐	☐	☐	☐	☐
7. Determined severity of panel damage	☐	☐	☐	☐	☐
8. Determined whether panel should be repaired or replaced	☐	☐	☐	☐	☐
9. Developed complete repair plan	☐	☐	☐	☐	☐
10. Sequenced repairs in appropriate and efficient order	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_____________

Unit 1: Structural Analysis and Damage Repair

Subunit 1.2: Unibody Inspection, Measurement, and Repair

Competency 1.2.7: Attach body anchoring devices

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Attach body anchoring devices
Criteria:	In accordance with the criteria in the checklist for Competency 1.2.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when attaching body anchoring devices in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Most anchoring devices are similar in the ways they attach to the vehicle. For each specific vehicle and type of anchoring device, however, there are variations.
2. Therefore, it is critical to follow the manufacturer's specifications for attaching and positioning each anchoring device. Otherwise, the result could be damage to the vehicle.

References:

Service manuals; technical service bulletins (TSBs); product information from frame/anchoring device manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Pinchweld Clamp	2. This is the most commonly used anchoring device for unibody vehicles. Two types: • Horizontal • Vertical (most common)
3. Using Pinchweld Clamp	3. Check manufacturer's specifications for correct positioning so vehicle will be anchored at strongest points. Check for clearance around fuel lines, brake lines, cables, etc., before tightening clamp so they will not be crushed or broken. Tighten clamps and torque to manufacturer's specifications to prevent damage to anchoring device or vehicle. • Too tight—could damage clamp and/or rip metal • Too loose—body will not be properly secured

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover torque in relation to nuts and bolts.

Review:

Ask students review questions such as the following:

1. What type of anchoring device is used for most unibody vehicles? Why are anchoring devices used?
2. If manufacturer's recommendations are not followed when placing and attaching anchoring devices, what could be the result?

Application:

1. As students practice attaching anchoring devices to given vehicles, quiz them individually on the process (e.g., ask them to demonstrate how to check the clearance around fuel lines, etc.). This can be done on an individual or team basis.

Evaluation:

√ The student will attach body anchoring devices. His/her performance will be evaluated using a copy of the performance checklist for Competency 1.2.7.

Competency 1.2.7: Attach body anchoring devices

Performance Checklist

In attaching body anchoring devices, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Identified vehicle and/or equipment manufacturer's specifications for attaching and positioning anchor device	☐	☐	☐	☐	☐
4. Positioned anchoring device in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Ensured that anchoring device was clear of all cables and lines	☐	☐	☐	☐	☐
6. Attached anchoring device in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Torqued anchoring device in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 1: Structural Analysis and Damage Repair

Subunit 1.2: Unibody Inspection, Measurement, and Repair

Competency 1.2.16: Remove creases and dents using power tools and hand tools to restore damaged areas to proper contours and dimensions

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Remove creases and dents using power tools and hand tools
Criteria:	In accordance with the criteria in the checklist for Competency 1.2.16

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when removing creases and dents using power tools and hand tools. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Unibody vehicles utilize a variety of high-strength steels (HSS), and excessive use of heat or force can weaken these metals.
2. Returning metal to its original ***shape*** is not the same as returning it to its original ***state***.
   - When repairing structural panels, the metal must be restored to the correct ***shape***—in other words, the panel must be reformed to its original contours.
   - The metal must also be restored to the correct ***state***—in other words, the molecular structure of the metal must be corrected.
   - Restoring shape and state is known as stress-relieving.
   - These techniques can be performed in different ways using different tools.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Refer to repair plan for manufacturer's recommendations.
3. Determining Stress-Relief Method	3. Possible methods: • Shock relief • Heat (oxyacetylene torch) • Port-o-powers or body jacks • Spoons, dollies, and pry bars
4. Using Shock Relief Method	4. Use pressure and various body and bumping hammers at stress point to relieve stress. Select size and weight of hammer appropriate for area being repaired. There should be pulling pressure, which is using a frame rack or straightening equipment with either shock relief or heat. Use shock method first. If that doesn't work, use shock and heat simultaneously.

Presentation Outline	Steps to Cover/Key Points to Make
5. Using Heat Method	5. There should be minimal use of heat to relieve stress because heat affects the molecular structure of the metal. Remove all flammable material from area being heated. Use a heat crayon to gauge metal temperature. Apply heat using an oxyacetylene torch. If, after using heat twice in the same area, the part has still not returned to its original shape, you should ***replace*** the part. Allow metal to cool naturally (do ***not*** use water or compressed air).
6. Using Port-o-Power	6. The port-o-power is a hydraulic body jack used to apply pressure, which aids in stress relief. The equipment may be air-powered or manually operated.
7. Using Spoons, Dollies, and Pry Bars	7. Spoons, dollies, and pry bars are used to gain access to damaged areas. Dollies are used like anvils. Spoons come in a variety of shapes and sizes and are used like hammers and dollies. Pry bars are used to reach confined areas where there is limited access.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on metallurgy, molecular structure of metals, and principles of force.

Review:

Ask students review questions such as the following:

1. What is involved in the shock relief method of stress relief?
2. What is involved in the heat relief method of stress relief?
3. What is the difference between the meanings of *shape* and *state*?

Application:

1. Provide students with a vehicle with structural damage, and ask them to locate manufacturer's recommendations and determine procedures necessary for stress-relieving the damaged metal using hand and power tools.
2. As students practice stress-relieving metal on a vehicle with structural damage, quiz them individually on the process (e.g., ask them to explain how they selected which stress-relief method(s) to use).

Evaluation:

√ The student will remove creases and dents using power tools and hand tools. His/her performance will be evaluated using a copy of the performance checklist for Competency 1.2.16.

Competency 1.2.16: Remove creases and dents using power tools and hand tools to restore damaged areas to proper contours and dimensions

Performance Checklist

In removing creases and dents using power tools and hand tools, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to repair plan for manufacturer's recommendations	☐	☐	☐	☐	☐
3. Determined best repair method to use	☐	☐	☐	☐	☐
4. Selected hand and power tools needed to complete repairs	☐	☐	☐	☐	☐
5. Restored metal to original shape	☐	☐	☐	☐	☐
6. Stress-relieved metal to original state	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.1/2.5.1: Identify weldable and non-weldable materials used in collision repair and refinish components

Competencies 1.4.3/2.5.3: Determine the correct welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Determine the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation

Criteria: In accordance with the criteria in the checklist for Competencies 1.4.1/2.5.1 & 1.4.3/2.5.3

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when determining the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation. Show videos that show the materials, equipment, and steps used in welding processes.

Competency-Specific Information:

1. Present stories, news articles, etc., that illustrate the fact that deaths can result from incorrect welds made during vehicle repair.

2. Emphasize responsibility of every technician for being able to correctly identify weldable and non-weldable materials.

3. Show materials and equipment used in different welding processes.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Identifying Weldable and Non-Weldable Materials	2. To determine whether or not metals should be welded, you need to consider two things: • Characteristics • Location Characteristics of weldable materials: • Have fine grain structure, high luster • Accept the electrode metal Characteristics of non-weldable materials: • Have course grain structure, low luster • Do not accept the electrode metal To identify those characteristics, visually inspect a cross-section of the metal (not a polished surface). To identify whether the part is in a weldable location, use the appropriate chart in manufacturer's and/or I-CAR related tech manuals. • Locating appropriate chart • Interpreting charts

Presentation Outline	Steps to Cover/Key Points to Make
3. Selecting Correct Welder Type	3. Types of welders: • MIG (metal inert gas); also called GMAW (gas metal arc welding) • TIG (tungsten inert gas) • Oxyacetylene • ARC (electric arc) For collision repair— • MIG/GMAW is most often used. • TIG is rarely used. • Oxyacetylene and ARC are not used and not recommended. To select appropriate type of welder for a given task, check the manufacturer's specifications concerning the location of the weld. I-CAR and vehicle manufacturers recommend MIG welding as the preferred method for welding unibody vehicles.
4. Selecting Correct Electrode	4. Electrodes need to match manufacturer's specifications for the specific welder. Selected electrode needs to be appropriate for the following: • Position of weld • Type of metal (e.g., steel, aluminum) • Thickness of metal
5. Selecting Correct Wire Type and Diameter	5. Wires are typed by two factors: • Type of metal (e.g., steel, aluminum) • Tensile strength Tensile strength is measured in foot pounds. A number on the wire—assigned by the American Welding Society—can be used to look up its tensile strength.

Presentation Outline	Steps to Cover/Key Points to Make
	Wire diameters are identified to the nearest thousandths of an inch. Wire diameters in collision repair: • 0.023"—most commonly used • 0.030"—not used extensively • 0.035"—used mainly in frame repair Guidelines for selecting appropriate wire type and diameter for a given task: • Select wire type in accordance with welding equipment manufacturer's specification charts. • Use high-tensile wire for structural repair. • Low-tensile wire can be used for non-structural repair. • Select wire diameter based on the thickness of the metal. **Key Point:** Thicker metal requires thicker-diameter wire.
6. Selecting Correct Gas	6. Types of gas: • Argon • CO_2 • CO_2/Argon mix • Helium The appropriate gas to use is based primarily on the type of metal to be welded. For example: • Argon must be used for aluminum. • CO_2 or CO_2/Argon is used for steel. • CO_2/Argon is the preferable gas to use on high-strength steel because it maintains a smaller heat zone. • CO_2—a cheaper gas—is sometimes an acceptable alternative for use on high-strength steel, but the heat zone is larger. • Helium is used for steel. **Key Point:** Whenever you are selecting a gas for use in welding, environmental and health concerns should also be an issue.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could develop students' understanding of (1) porosity and how it affects welds and the welding process; (2) tensile strength and its measurement in foot pounds; and (3) gases used in welding, their characteristics, their effects on metal, and related environmental and health issues. The applied math teacher could help students measure in foot pounds and understand the differences in wire diameters (e.g., by measuring their diameter using a micrometer).

Review:

Ask students review questions such as the following:

1. What makes a material non-weldable?
2. What are some examples of the locations where weldable and non-weldable materials can be found?
3. What are the major determining factors in selecting the correct materials and equipment for a specific welding situation?

Application:

1. Provide students with a variety of metals (e.g., aluminum, cast aluminum, cast iron, mild steel, high-strength steel, high-strength/low-alloy steel), and have them work individually to determine weldable/non-weldable characteristics of those metals. **Note:** Some non-metals could be included to ensure that students can differentiate between metals and non-metals. Have students compare their findings.
2. Provide students with common parts—both weldable (portions of frame rails, rocker area parts, B-pillars, quarter panels) and non-weldable (portions of frame rails, suspension parts)—and ask them to determine whether each part should be welded. This can be done on an individual, small-group, or whole-class basis.
3. For each of the weldable parts in #2 above, have students list materials and equipment needed to perform a specific type of weld.

Evaluation:

√ The student will determine the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.1/2.5.1 & 1.4.3/2.5.3.

Competencies 1.4.1/2.5.1: Identify weldable and non-weldable materials used in collision repair and refinish components

Competencies 1.4.3/2.5.3: Determine the correct welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation

Performance Checklist

In determining the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Accurately determined whether material was weldable or non-weldable by checking the following:					
a. Material's characteristics	☐	☐	☐	☐	☐
b. Appropriate chart (manufacturer, I-CAR) on weldable locations	☐	☐	☐	☐	☐
3. Selected correct materials and equipment for given situation and manufacturer's specifications, including—					
a. Type of welder	☐	☐	☐	☐	☐
b. Type of electrode	☐	☐	☐	☐	☐
c. Type of wire	☐	☐	☐	☐	☐
d. Diameter of wire	☐	☐	☐	☐	☐
e. Type of gas	☐	☐	☐	☐	☐
4. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform welds
Criteria:	In accordance with the criteria in the checklists for Competencies 1.4.2/2.5.2 & 1.4.14/2.5.14

Introduction:

General Introductory Techniques: Share personal experiences you have had when performing various welds in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Show students pictures and locations of each of these different types of welds. If possible, also show the welds on an actual vehicle in the lab.

2. Show students both high-quality and low-quality welds, and have them compare and list the differences.

3. Show students different types of welding equipment.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Set up equipment for performing specific weld in accordance with accepted procedures (1.4.4/2.5.4–1.4.7/2.5.7). Operate welding equipment following accepted procedures for producing a quality weld (1.4.8/2.5.8) **Key Point:** On thicker metals, a slight weaving motion of the gun may be needed in a specific welding process to ensure proper penetration and bead buildup.
3. **Tack Welds:** Characteristics	3. Tack welds are foundational welds for performing other welding operations. For example, tack welds should be made every 2"–3" along the welding joint prior to performing a continuous or stitch weld. Using tack welds in this manner maintains alignment and prevents distortion during other welding operations. When the other weld is made, the tack weld should blend in with it. A quality tack weld— • is round in appearance; • has equal penetration to all pieces; • has no undercut; and • has minimal bead buildup.

Presentation Outline	Steps to Cover/Key Points to Make
4. Performing Tack Welds	4. Position gun equally between all pieces to be welded. Hold gun steady (there must be no movement of the gun). Pull the trigger to release welding wire. Release wire to form a circle of sufficient size to penetrate and join all pieces.
5. **Continuous Welds:** Characteristics	5. A quality continuous weld— • has an even pattern of ripples throughout the weld; • has a convex appearance; • has little or no undercut; • is free of splattered material; • is bright and free of *scales* (excess loose metal); • has equal penetration to all pieces; • has a bead that is in line with the weld joint; and • extends the full length of the joint. **Key Point:** A common error in continuous welding is failing to start or finish at the ends of the joint. Incomplete welds—welds that do not extend the full distance—have points that lead to weld failure.
6. Performing Continuous Welds	6. Position gun equally between all pieces to be welded. At the edge of the metal, pull the trigger to release wire. Move the gun in the direction of the joint at a steady rate of speed that permits proper bead height without undercut. **Key Point:** Speed also affects rippling. Using an unsteady speed results in unequal ripple size and poor weld quality. Continue the process over the full extent of the joint.

Presentation Outline	Steps to Cover/Key Points to Make
7. **Stitch Welds:** Characteristics	7. A quality stitch weld has all the characteristics of a continuous weld and should be indistinguishable from it if completed properly.
8. Performing Stitch Welds	8. A stitch weld is performed using a process nearly identical to that used for a continuous weld. The only ***difference*** is that in performing a stitch weld, the welding gun is frequently triggered on and off. The on/off cycling is determined by the thickness of the metals being welded and/or the speed of welding. On/off cycling can be manual or automatic, depending on the type of machine. **Key Point:** The gun should be moved only during the ON part of the cycle. The gun must be held steady during the OFF part of the cycle
9. **Lap Welds:** Characteristics	9. Lap welds connect overlapping pieces of metal. The weld joint runs along the edge of the upper piece of metal. A quality lap weld has many of the same characteristics as a continuous weld, except for the differences resulting from the overlap of the pieces. Thus, a quality lap weld— • has total penetration on the bottom piece; • is convex enough to absorb the edge of the upper piece of metal; and • has no undercut on the upper edge of the upper piece of metal.

Presentation Outline	Steps to Cover/Key Points to Make
10. Performing Lap Welds	10. Position the weld gun at a 45° angle to the welding surface and at a 45° angle to the edge of the upper piece of metal. Use a slight weaving motion as you move the gun along the joint to be welded, going from upper to lower pieces. Maintain a speed that produces a convex weld between the pieces, without causing an undercut.
11. **Plug Welds:** Characteristics	11. Plug welds connect overlapping pieces and are used to replace factory-produced spot welds. The plug welds should duplicate the size and number of factory welds to restore the vehicle to manufacturer's specifications. A quality plug weld— • is 5/16"–3/8" in size; • totally penetrates the lower pieces of metal, leaving a small bump on its back side; • totally fills the drilled hole of the upper piece; and • has a convex surface.
12. Performing Plug Welds	12. Drill 5/16"–3/8" hole in upper piece of metal. Position the gun at a 75°–90° angle to the hole. Trigger release of wire. Immediately rotate gun around hole until hole is filled and convex surface is formed.

Presentation Outline	Steps to Cover/Key Points to Make
13. **Spot Welds:** Characteristics	13. Spot welds are welded spots between two overlapping pieces of metal. They are only acceptable when done by electrical resistance processes performed with pressure-type (clamp) equipment. The spot welds should duplicate the size and number of factory welds. A quality spot weld— • is slightly indented on the top piece of metal; and • is slightly convex on the back piece.
14. Performing Resistance Spot Welds	14. Adjust welding machine timer to ensure total penetration. Place resistance contacts to metal. Pull trigger to release electric current. Wait for timer to shut off.
15. **Reinforced-Butt Welds:** Characteristics	15. A reinforced-butt weld involves three pieces of metal. One piece is placed below the other two pieces and the joint to be welded. A reinforced-butt weld is a combination of plug, tack, and continuous welding, respectively; and a quality reinforced-butt weld should have the desired characteristics of each. All pieces of metal must fit tightly together.
16. Performing Reinforced-Butt Welds	16. Drill 5/16" holes in upper pieces of metal, 2"–3" apart. Position the three pieces for welding. Perform plug welds. Perform tack welds. Perform continuous weld.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on the molecular structure of metals, the making of metals, characteristics of different types of metals, effects of heat on metal (e.g., distortion), and heat transfer in metals. The applied mathematics teacher could work with students on techniques for measuring temperatures during the welding process.

Review:

Ask students review questions such as the following:

1. What characteristics do quality lap, stitch, continuous, and reinforced butt welds have in common?
2. Why are plug and spot welds used on vehicles, and what is the proper method for using these types of welds?
3. What is the purpose of the weaving motion used with the welding gun?

Application:

1. As students practice performing different welds, quiz them individually on the process (e.g., ask them to explain the quality criteria for the particular weld they are performing).
2. Ask students to evaluate each of their practice welds using the quality criteria for that type of weld and select their three best welds to submit to the instructor.

Evaluation:

√ The student will perform welds. His/her performance will be evaluated using a copy of the performance checklists for Competencies 1.4.2/2.5.2 & 1.4.14/2.5.14. There is one checklist for each of the seven types of welds to be performed..

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing continuous welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun equally between all pieces to be welded	☐	☐	☐	☐	☐
4. Pulled trigger to release welding wire at edge of metal	☐	☐	☐	☐	☐
5. Moved gun in direction of joint	☐	☐	☐	☐	☐
6. Moved gun at steady rate of speed that permitted proper bead height without undercut	☐	☐	☐	☐	☐
7. Continued process over full extent of joint	☐	☐	☐	☐	☐
8. Produced a continuous weld that met the following quality criteria:					
a. Had an even pattern of ripples throughout weld	☐	☐	☐	☐	☐
b. Had a convex appearance	☐	☐	☐	☐	☐
c. Had little or no undercut	☐	☐	☐	☐	☐
d. Was free of splattered material	☐	☐	☐	☐	☐
e. Was bright and free of scales	☐	☐	☐	☐	☐
f. Had equal penetration to all pieces	☐	☐	☐	☐	☐
g. Had a bead that was in line with the weld joint	☐	☐	☐	☐	☐
h. Extended the full length of the joint	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 1.4.2/2.5.2: Weld [and cut] high-strength steel and other metals using manufacturer's procedures

Competencies 1.4.14/2.5.14: Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing stitch welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun equally between all pieces to be welded	☐	☐	☐	☐	☐
4. Pulled trigger to release welding wire at edge of metal	☐	☐	☐	☐	☐
5. Moved gun in direction of joint	☐	☐	☐	☐	☐
6. Triggered gun on and off frequently in accordance with thickness of metals being welded and/or speed of welding	☐	☐	☐	☐	☐
7. Moved gun only during ON part of cycle, with gun held steady during OFF part of cycle	☐	☐	☐	☐	☐
8. Continued process over full extent of joint	☐	☐	☐	☐	☐
9. Produced a stitch weld that met the following quality criteria:					
a. Had an even pattern of ripples throughout weld	☐	☐	☐	☐	☐
b. Had a convex appearance	☐	☐	☐	☐	☐
c. Had little or no undercut	☐	☐	☐	☐	☐
d. Was free of splattered material	☐	☐	☐	☐	☐
e. Was bright and free of scales	☐	☐	☐	☐	☐
f. Had equal penetration to all pieces	☐	☐	☐	☐	☐
g. Had a bead that was in line with the weld joint	☐	☐	☐	☐	☐
h. Extended the full length of the joint	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

1.4.2/2.5.2 & 1.4.14/2.5.14

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing tack welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun equally between all pieces to be welded	☐	☐	☐	☐	☐
4. Held gun steady, with no movement	☐	☐	☐	☐	☐
5. Pulled trigger to release welding wire	☐	☐	☐	☐	☐
6. Released wire to form circle of sufficient size to penetrate and join all pieces	☐	☐	☐	☐	☐
7. Produced a tack weld that met the following quality criteria:					
a. Was round in appearance	☐	☐	☐	☐	☐
b. Had equal penetration to all pieces	☐	☐	☐	☐	☐
c. Had no undercut	☐	☐	☐	☐	☐
d. Had minimal bead buildup	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 1.4.2/2.5.2: Weld [and cut] high-strength steel and other metals using manufacturer's procedures

Competencies 1.4.14/2.5.14: Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing plug welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Drilled 5/16"–3/8" hole in upper piece of metal	☐	☐	☐	☐	☐
4. Positioned gun at 75°–90° angle to hole	☐	☐	☐	☐	☐
5. Pulled trigger to release welding wire	☐	☐	☐	☐	☐
6. Rotated gun around hole until hole was filled and convex surface was formed	☐	☐	☐	☐	☐
7. Produced a plug weld that met the following quality criteria:					
a. Was 5/16"–3/8" in size (duplicating factory size)	☐	☐	☐	☐	☐
b. Totally penetrated lower pieces of metal, leaving small bump on its back side	☐	☐	☐	☐	☐
c. Totally filled the drilled hole of the upper piece	☐	☐	☐	☐	☐
d. Had a convex surface	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**______________

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing spot welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Adjusted welding machine timer to ensure total penetration	☐	☐	☐	☐	☐
4. Placed resistance contacts to metal	☐	☐	☐	☐	☐
5. Pulled trigger to release electric current	☐	☐	☐	☐	☐
6. Waited for timer to shut off	☐	☐	☐	☐	☐
7. Produced a spot weld that met the following quality criteria:					
a. Was slightly indented on top piece of metal	☐	☐	☐	☐	☐
b. Was slightly convex on back piece	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing reinforced-butt welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Drilled 5/16" holes in upper pieces of metal, 2"–3" apart	☐	☐	☐	☐	☐
4. Positioned three pieces of metal correctly for welding	☐	☐	☐	☐	☐
5. Performed plug welds in accordance with accepted procedures for that type of weld	☐	☐	☐	☐	☐
6. Performed tack welds in accordance with accepted procedures for that type of weld	☐	☐	☐	☐	☐
7. Performed continuous weld in accordance with accepted procedures for that type of weld	☐	☐	☐	☐	☐
8. Produced a reinforced-butt weld that met the quality criteria for each type of weld (plug, tack, continuous)	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing lap welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun at 45° angle to welding surface and 45° angle to edge of upper piece of metal	☐	☐	☐	☐	☐
4. Moved gun along joint using a slight weaving motion, going from upper to lower pieces	☐	☐	☐	☐	☐
5. Maintained a speed that produced a convex weld between pieces without causing undercut	☐	☐	☐	☐	☐
6. Produced a lap weld that met the following quality criteria:					
a. Had total penetration on bottom piece	☐	☐	☐	☐	☐
b. Was convex enough to absorb edge of upper piece	☐	☐	☐	☐	☐
c. Had no undercut on upper edge of upper piece	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.2/2.5.2: [Weld and] cut high-strength steel and other metals using manufacturer's procedures

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid (e.g., a specific metal product to build), manufacturer's information, and while following all applicable safety guidelines
Behavior:	Cut high-strength steel and other metals
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.2/2.5.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when cutting high-strength steel and other metals in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain importance of use of high-strength steel in today's automobile industry and the potential dangers when it is repaired incorrectly.

2. Describe how previous information about high-strength steel is no longer accurate, and bring students up-to-date with the changes.

3. If possible, heat pieces of high-strength steel so students can observe how heat changes the characteristics of high-strength steel (cracks, stretches, weaknesses).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Tools for Cutting High-Strength Steel	2. Standard cutting tools: • Plasma cutter • Cut-off tool • Reciprocating saw • Spot weld cutter • Air chisel
3. Performing Cutting Operations: General Guidelines	3. Each tool should be used in accordance with manufacturer's specifications. In most cases, the tool should be positioned at a 90° angle to the metal surface. The preciseness required in cutting may vary depending on circumstances. If a precise layout diagram is provided, it must be followed. The process should maintain as small a heat zone as possible in order to avoid molecular damage and distortion to the surrounding high-strength steel.

Presentation Outline	Steps to Cover/Key Points to Make
4. Using Layout Diagrams	4. Read the diagram by interpreting— • scale; • angles; and • lines (bend, cut). Transpose the diagram to the metal according to scale using a measuring tool and a square, a triangle, and/or a compass. Etch lines into metal with a scratch-all. **Key Point:** When precise cutting is required, the cutting line should be the edge, not the center, of the cut. The cut should be on the outside of the cutting line.
5. Selecting Cutting Tools: General Guidelines	5. To select the appropriate cutting tool, you should consider the following: • Cutting procedure to be done (e.g., sectioning, spot weld cutting) • Location of the needed cut on the vehicle • Cleanliness of the metal (e.g., amount of rust, paint, or sealers) Since today's accepted cutting tools all provide a low heat zone when used properly, heat-zone size is no longer a factor for selection.
6. Using a Plasma Cutter	6. Selection factors: • Used for sectioning or spot weld cutting. • If the plasma cutter is to be used for spot weld cutting, you must have access to both sides of the metal. • Plasma cutter size is selected based on the thickness of metal to be cut. • Due to hot, molten sparks produced by the cutter, areas around the cutting location should not be combustible. Glass and chrome areas should be well protected. • Metal to be cut should be clean (free of rust, paint, sealants).

Presentation Outline	Steps to Cover/Key Points to Make
	Preparation: • Make sure the plasma cutter has the voltage needed to cut through the thickness of the metal. • Clean metal so that it is free of rust, paint, and sealant, using mechanical (grinding) and/or chemical processes (2.1.2/2.1.4/2.1.6/2.1.7/2.18). • Attach ground clamps (1.4.4/2.5.4). Cutting procedure: • Position plasma gun. • Pull trigger to begin cutting. • Make the cut to prescribed preciseness at a steady rate of speed.
7. Using a Cut-off Tool	7. Selection factors: • Used only for sectioning. • Cannot be used in confined areas (e.g., corners) where binding may occur. • Can be used to cut contaminated metals (painted, rusted, sealant-covered). Preparation: • Protect surrounding areas from hot sparks. • Adjust air pressure to manufacturer's specifications. • Select blade based on speed of grinder and type of metal to be cut. Cutting procedure: • Position the cutter. • Pull trigger to begin cutting. • Make the cut, holding the gun only tight enough to maintain control. Holding it too tight may cause binding.

Presentation Outline	Steps to Cover/Key Points to Make
8. Using a Reciprocating Saw	8. Selection factors: • Used only for sectioning. • Cannot be used in confined areas (e.g., corners) where binding may occur. • Can be used to cut contaminated metals. Preparation: • Select blade length and type based on type of metal and distance to be cut. • Attach selected blade. Cutting procedure: • Position the cutter. • Pull trigger to begin cutting. • Make the cut, holding the cutter tight against the surface.
9. Using a Spot Weld Cutter	9. Selection factors: • Used only for removal of factory spot welds. **Note:** This is the preferred tool for removing spot welds. • Can be used on a factory spot weld in any location. • Can be used to cut contaminated metals. Preparation: • Select blade diameter size that is large enough to remove entire spot weld. • Select drill with an RPM that matches the blade requirements. Cutting procedure: • Center drill with attached blade over spot weld. • Pull trigger to begin cutting. • Apply even pressure until the *stop* is reached. • Break spot weld cut with chisel to remove metal.

Presentation Outline	Steps to Cover/Key Points to Make
10. Using an Air Chisel	10. Selection factors: • Used for sectioning and spot weld cutting. • If used for sectioning, some minor warpage of metal (e.g., on non-structural parts) must be acceptable. • Can be used in any accessible location. • Can be used to cut contaminated metals. Preparation: • Adjust air pressure according to manufacturer's specifications. • Select appropriate well-sharpened chisel blade (e.g., a ripping blade for making rough cuts, a spot weld blade to break spot welds). **Key Point:** Chisel blades need to be very sharp for ease of cutting. Cutting procedure: • Position chisel with attached blade firmly against metal to be cut. • Pull trigger to begin cutting. • Make the cut using an even, steady pressure.
11. Welding High-Strength Steel	11. Follow standard procedures (1.4.2/2.5.2 & 1.4.14/2.5.14).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on the molecular structure of metals, the making of metals, characteristics of different types of metals, the history of steel, effects of heat on metal (e.g., distortion), and heat transfer in metals. The applied mathematics teacher could work with students on techniques for measuring temperatures during the welding process and for obtaining measurements from blueprints and the mathematics of using layout tools (e.g., squares, triangles, compasses).

Review:

Ask students review questions such as the following:

1. If high-strength steel is improperly welded, what could be the effects?
2. How does heat affect the molecular structure of steel?
3. If there is too large a heat zone during the welding of high-strength steel, what could be the possible results?

Application:

1. Have students cut metal using an acceptable procedure while the instructor uses a nonacceptable procedure (e.g., oxyacetylene cutting). Then ask the students to identify the size of the heat zones (e.g., using heat crayons) and determine whether they meet manufacturer's requirements.
2. Divide students into small groups, and ask them to examine a vehicle that will be scrapped from the program and to identify and label the various types of metal. Once you have verified their findings, have them practice cutting the different types of metal.

Evaluation:

√ The student will cut high-strength steel and other metals. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.2/ 2.5.2.

Competencies 1.4.2/2.5.2: [Weld and] cut high-strength steel and other metals using manufacturer's procedures

Performance Checklist

In cutting high-strength steel and other metals, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected tool(s) appropriate for specific cutting tasks	☐	☐	☐	☐	☐
3. Selected tool(s) appropriate for specific welding tasks	☐	☐	☐	☐	☐
4. Performed cuts in accordance with generally accepted procedures for each of the following tools:					
a. Plasma cutter	☐	☐	☐	☐	☐
b. Die grinder	☐	☐	☐	☐	☐
c. Metal saw cutter	☐	☐	☐	☐	☐
d. Spot weld cutter	☐	☐	☐	☐	☐
e. Air chisel	☐	☐	☐	☐	☐
5. Followed layout diagram exactly in making cuts	☐	☐	☐	☐	☐
6. Performed welds in accordance with equipment manufacturer's specifications	☐	☐	☐	☐	☐
7. Maintained proper heat zones during cutting and welding	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**________________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.4/2.5.4: Set up welding equipment
Competencies 1.4.5/2.5.5: Adjust the welder to "tune" for proper electrode stickout, voltage, polarity, flow rate, and wire-feed speed required for the material being welded
Competencies 1.4.6/2.5.6: Store, handle, and install high-pressure gas cylinders
Competencies 1.4.7/2.5.7: Determine work clamp (ground) location and attach
Competencies 1.4.8/2.5.8: Use the proper angle of the gun to the joint and the direction of the gun travel for the type of weld being made in the flat, horizontal, vertical, and overhead positions

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Set up, adjust, operate, and maintain welding equipment

Criteria: In accordance with the criteria in the checklist for Competencies 1.4.4/2.5.4–1.4.8/2.5.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when setting up, adjusting, operating, and maintaining welding equipment in the collision repair facility. Show videos related to welding equipment setup.

Competency-Specific Information:

1. Emphasize relationship of proper equipment setup to safety, work efficiency, and quality welds. Give examples of situations in which improper setup has caused problems and cost time and money.

2. Explain how angle and direction of welding gun can affect weld quality.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Setting Up Welding Equipment for a Specific Operation: General Guidelines	2. Select correct materials and equipment (1.4.1/2.5.1 & 1.4.3/2.5.3). Ensure sufficient reach of welding equipment to welding work area. Check that ground cables are in place on welding equipment. Attach ground clamps to welding object. **Key Point:** Ground clamps must be attached to clean, bare metal in close proximity to welding area.
3. Setting Up MIG Equipment	3. In addition to general setup procedures, you need to do the following: • Install the welding wire, electrode, and gas nozzle, respectively, in accordance with manufacturer's specifications. • Install the high-pressure gas cylinder. **Key Point:** The cylinder should always be chained in place during storage and installation. • Install the flow meter. **Key Points:** Before installation of flow meter, always purge the cylinder. After installation, always check the flow meter for leaks.

Presentation Outline	Steps to Cover/Key Points to Make
4. Adjusting Welding Equipment: General Guidelines	4. Follow manufacturer's specifications for voltage, wire-feed speed, related gas pressure, tip size, wire size, and flow rate, as applicable. Each of these specifications will vary by manufacturer and by type of welding equipment.
5. Adjusting MIG Equipment	5. In addition to general adjustment procedures, you need to do the following: • Use manufacturer's specifications to determine proper adjustment of voltage, polarity, wire-feed speed, and flow rate for the specific material to be welded. **Note:** When properly adjusted, the welding sound is much like bacon frying. • Adjust stickout based on anticipated angle and direction of welder gun use (1/4"–1/2"). **Key Point:** Stickout should never be more than 1/2" or less than 1/4".
6. Operating Welding Equipment	6. Keep the welder at a 45°–60° angle in line with the direction of the weld. **Key Points:** • If proper equipment and materials have been selected, maintaining a 45°–60° angle ensures proper laydown of welding material. • If you have to deviate from the 45°–60° angle, pay close attention to the welding puddle to ensure complete penetration and weld laydown. Move the welding gun (drag, push) so that you maintain visibility of the welding puddle, regardless of weld position.

Presentation Outline	Steps to Cover/Key Points to Make
	Key Points: • While welding in an overhead position, always pull the weld puddle toward self in order to maintain visibility of puddle. • *Blind welding*—welding without being able to see the puddle—occurs when this rule is violated. • Overhead welding requires particular attention to safety and use of safety equipment.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on how to cost-out a welding operation and how rheostats calculate rate of delivery. The applied science teacher could discuss the use of electricity in welding; electrocution hazards; voltage, resistance, polarity, and flow rate; and how rheostat controls motor speed.

Review:

Ask students review questions such as the following:

1. What general concerns should be addressed in setting up welding equipment?
2. What sequence should be followed in setting up a MIG welder?
3. Where would you position a ground clamp, and why?
4. What is blind welding, and why is it a problem?

Application:

1. Give students written case studies describing various welding situations, and ask them to select the correct equipment angle and direction for each situation and to justify their answers.

2. Provide students with a variety of welds—some done with proper equipment angle and direction, and some done with improper angle and direction—and ask them to determine the effects of angle and direction on the quality of each weld.

3. Divide students into teams and assign each to design a poster, bulletin board, or video about one of the following:
   - Proper and improper angles and directions for welding operations and impact on weld quality
   - Welding equipment setup and procedures, including safety concerns
   - Storage, handling, and installation of high-pressure gas cylinders
   - Proper and improper grounding procedures
   - Procedure for tuning a MIG welder

4. Ask students to set up equipment using the team-prepared directions and provide feedback on the quality of the directions (ease of use, completeness, accuracy, etc.).

Evaluation:

√ The student will set up, adjust, operate, and maintain welding equipment. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.4./2.5.4–1.4.8/2.5.8.

Competencies 1.4.4/2.5.4:	Set up welding equipment
Competencies 1.4.5/2.5.5:	Adjust the welder to "tune" for proper electrode stickout, voltage, polarity, flow rate, and wire-feed speed required for the material being welded
Competencies 1.4.6/2.5.6:	Store, handle, and install high-pressure gas cylinders
Competencies 1.4.7/2.5.7:	Determine work clamp (ground) location and attach
Competencies 1.4.8/2.5.8:	Use the proper angle of the gun to the joint and the direction of the gun travel for the type of weld being made in the flat, horizontal, vertical, and overhead positions

Performance Checklist

In setting up, adjusting, operating, and maintaining welding equipment, the student—

	1	**2**	**3**	**4**	**5**
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected proper materials and equipment for the specific welding operation	☐	☐	☐	☐	☐
3. Ensured setup had sufficient electrical supply	☐	☐	☐	☐	☐
4. Stored, handled, and installed gas cylinders properly	☐	☐	☐	☐	☐
5. Adjusted MIG welder to manufacturer's specifications, including—					
a. Stickout	☐	☐	☐	☐	☐
b. Voltage	☐	☐	☐	☐	☐
c. Polarity	☐	☐	☐	☐	☐
d. Flow rate	☐	☐	☐	☐	☐
e. Wire-feed speed	☐	☐	☐	☐	☐
6. Operated welding equipment using proper angle and direction for each welding position, including—					
a. Flat	☐	☐	☐	☐	☐
b. Horizontal	☐	☐	☐	☐	☐
c. Vertical	☐	☐	☐	☐	☐
d. Overhead	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.9/2.5.9:	Protect adjacent panels, glass, vehicle interior, etc., from welding and cutting operations
Competencies 1.4.10/2.5.10:	Protect computers and other electronic control modules during welding procedures according to manufacturer's specifications
Competencies 1.4.11/2.5.11:	Clean and prepare the metal for welding; fit, align, and clamp as required

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Prepare a vehicle for welding and cutting operations
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.9/2.5.9–1.4.11/2.5.11

Introduction:

General Introductory Techniques: Share personal experiences you have had when preparing vehicles for welding and cutting operations in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Give examples of damage that occurred during welding operations as a result of poor protection and the consequences of that damage in terms of labor and costs. Emphasize that simple repairs can turn into major repairs as a result of carelessness (e.g., welding sparks embedded in glass or chrome, damaged computers and other electronic parts).

2. Give examples of improper fit and alignment and the impact in terms of additional work, downtime, and cost of the job.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4). Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safety Practices	2. For welding, fire extinguishment procedures and personal safety equipment should be a special focus.
3. Protecting Vehicle Parts During Cutting and Welding to Prevent Damage	3. Determine all vehicle parts (interior and exterior) that could be damaged during welding and cutting procedures. Determine whether part needs to be removed or protected in place. Determine type of potential damage to part. **Key Point:** The most common causes of damage are sparks, heat, and dust. To protect against spark damage: • Use nonflammable coverings (metal pieces, fire blankets). • Can use protective tapes on exterior glass and metal and plastic parts. To protect against potential dust damage: • Use plastic sheets or paper to cover the parts. **Key Point:** This applies to dust damage only—and only in areas where no potential damage from sparks or heat is possible. • Special attention should be given to dash assembly, openings, and cloth interior parts.

Presentation Outline	Steps to Cover/Key Points to Make
	To protect against heat damage: • Remove interior parts or exterior trim (preferred method). • Protect with a heat absorbent material (e.g., heat dam) if parts are not easily removed. **Key Point:** Do not use asbestos material for heat protection.
4. Protecting Computers and Other Electronics from Electrical Damage	4. Use manufacturer's service manuals to determine special precautions and locations of electronic controls. Follow manufacturer's specifications for protection. **Key Point:** For some controls, removal is required. For others, disconnection of ground and battery power wire is all that is necessary.
5. Pre-Measuring Parts and Welding Areas	5. Proper measurement prior to welding is critical to ensure fit and alignment of parts after the welding operation is completed and to prevent having to redo a welding operation. Pre-measure part(s) and surrounding area. Important measurements include length, width, and X. For proper fit, the gap between the two parts to be welded must be no wider than the thickness of the metal. For alignment, check manufacturer's specifications to identify proper sizes of opening gaps. If fit is improper, a cutting operation may be needed in order to get a proper fit (1.4.2/2.5.2). **Key Point:** When a cutting operation is needed, the cutting width must be accounted for during pre-measurement. Different cutting tools have different cutting widths, which affects the final measurements.

Presentation Outline	Steps to Cover/Key Points to Make
6. Cleaning Welding Areas	6. Clean all welding areas as follows: ◆ Steel needs to be cleaned to bare surface. ◆ For galvanized, remove paint but leave galvanized coating. **Key Point:** Although some of the galvanized layer must be removed, leave as much as possible. During welding, it remelts and heals the welded area with a galvanized coating.
7. Applying Primer	7. Apply a weld-through primer on areas that will not be accessible after completion of the welding operation.
8. Clamping Parts	8. Parts must be clamped for sufficient support and maintenance of proper fit and alignment measurement.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover measurement in relationship to fit and alignment work, helping students learn to measure in millimeters. Geometric concepts could be taught in relationship to learning to make X-measurements. The applied science teacher could provide lessons about galvanization processes and how computer and electronic controls can be damaged during cutting and welding operations.

Review:

Ask students review questions such as the following:

1. What is the importance of making proper measurements prior to welding?
2. What are the most common causes of damage to vehicle parts during welding and cutting operations?
3. How does computer and electronic control damage occur during welding and cutting operations?
4. What is the difference between the welding preparation procedures used for steel and galvanized steel?

Application:

1. Give students written case studies describing different welding and cutting situations, and ask them to describe how to protect each vehicle (parts, computers, electronic controls) during the welding or cutting operation.
2. Provide students with pieces of metal, and ask them to prepare them for welding as if they were vehicle parts. Then have students exchange parts and review each other's work for cleanliness and fit.

Evaluation:

√ The student will prepare a vehicle for welding and cutting operations. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.9/2.5.9–1.4.11/2.5.11.

Competencies 1.4.9/2.5.9:	Protect adjacent panels, glass, vehicle interior, etc., from welding and cutting operations
Competencies 1.4.10/2.5.10:	Protect computers and other electronic control modules during welding procedures according to manufacturer's specifications
Competencies 1.4.11/2.5.11:	Clean and prepare the metal for welding; fit, align, and clamp as required

Performance Checklist

In preparing a vehicle for welding and cutting operations, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Accurately determined possibility of damage to parts by sparks, dust, heat	☐	☐	☐	☐	☐
4. Accurately determined possibility of damage to computer and electronics controls	☐	☐	☐	☐	☐
5. Selected proper protection procedure, including—					
a. Removal of part(s)	☐	☐	☐	☐	☐
b. Coverage of part(s)	☐	☐	☐	☐	☐
c. Disconnection from power source and ground	☐	☐	☐	☐	☐
6. Properly applied selected protection materials	☐	☐	☐	☐	☐
7. Correctly measured parts and surrounding area	☐	☐	☐	☐	☐
8. Cleaned area and removed coatings using procedure appropriate for type of metal	☐	☐	☐	☐	☐
9. Properly clamped parts for support, fit, and alignment	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.12/2.5.12:	Determine the joint type (reinforced-butt, lap, etc.) for weld being made according to manufacturer's/industry specifications
Competencies 1.4.13/2.5.13:	Determine the type of weld (continuous, reinforced-butt, plug, etc.) for each specific welding operation according to manufacturer's/industry specifications

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Determine joint type and type of weld for each specific welding operation

Criteria: In accordance with the criteria in the checklist for Competencies 1.4.12/2.5.12 & 1.4.13/2.5.13

Introduction:

***General Introductory Techniques*:** Share personal experiences you have had in the collision repair facility when determining joint type and type of weld for each specific welding operation. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Discuss the effects of vibration and stress on auto body structure over time, and show examples of welds that have not held up.

2. Discuss the effect of improper weld joints on overall structural integrity, and explain what can happen in an accident.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Determining Joint Type	2. Type of joint to be made is determined by two factors: • Location of joint on vehicle • Whether the repair area is structural or non-structural For structural repairs in most areas, the original joint must be closely duplicated. However, a reinforced-butt joint is acceptable in non-weight-bearing areas. For non-structural repairs, the new joint may or may not be the same as the original joint. In many instances, a new joint is created through sectioning. In high-vibration areas, a reinforced joint (lap, reinforced-butt) must be made.

Presentation Outline	Steps to Cover/Key Points to Make
3. Determining Weld Type	3. Type of weld to be made is determined by type of joint to be made. For structural repairs, use joints that duplicate the original welds, resistance-spot welds, and plug welds. **Note:** It is impossible to duplicate a factory weld in most collision repair facilities. The above welds come closest to matching the original welds. Any structural repair that is done by sectioning requires a reinforced-butt weld. For non-structural repairs, a lap weld can be used in low-vibration areas. In high-vibration areas, a reinforced-butt weld is required.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss and/or demonstrate the effects of vibration on molecular structure.

Review:

Ask students review questions such as the following:

1. What are the major determining factors in deciding what type of joint to use?
2. How should you determine the type of weld to be made?

Application:

1. Provide students with pictures of damaged auto body parts, and ask them to determine whether weld joints are needed in each case. Where weld joints are needed, have students identify the proper joint to be made and welds needed to make the joint. Ask them to justify their decisions.
2. Provide students with examples of weld joint types, and have them identify each and explain (a) where the joint can be used, and (b) what welds were used to create the joint.

Evaluation:

√ The student will determine joint type and type of weld for each specific welding operation. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.12/2.5.12 & 1.4.13/2.5.13.

Competencies 1.4.12/2.5.12:	Determine the joint type (reinforced-butt, lap, etc.) for weld being made according to manufacturer's/industry specifications
Competencies 1.4.13/2.5.13:	Determine the type of weld (continuous, reinforced-butt, plug, etc.) for each specific welding operation according to manufacturer's/industry specifications

Performance Checklist

In determining joint type and type of weld for each specific welding operation, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Correctly identified type of repair area: structural or non-structural	☐	☐	☐	☐	☐
3. Determined whether weld would be made in a stress or vibration area	☐	☐	☐	☐	☐
4. Identified type of joint appropriate for specific location	☐	☐	☐	☐	☐
5. Identified type of weld appropriate for joint to be made	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________ **Date**____________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.15/2.5.15: Perform destructive tests on each weld type

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform destructive tests on each weld type
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.15/ 2.5.15

Introduction:

***General Introductory Techniques**:* Share personal experiences you have had when performing destructive tests on welds in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Explain the importance of performing destructive tests on practice welds (e.g., liability issues, ability to make adjustments before actual welding process).

2. Welds are usually tested using expensive, sophisticated equipment, but the technician can perform a destructive test with simple hand and power tools .

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Types of Welds To Be Tested	2. Butt weld Reinforced-butt weld Lap weld Plug weld Resistance spot weld
3. Performing Destructive Tests	3. Create a practice panel weld of same type and thickness as weld to be performed. **Note:** Duplicate original as closely as possible. Butt weld/lap weld destructive test: ◆ Place panel in a vise, with the jaws just below the weld. ◆ Bend the panel back and forth until it breaks. ◆ Panel should break on either side of the weld, but not at the weld itself. Reinforced-butt weld destructive test: ◆ Place panel in a vise, with the jaws just below reinforcement area. ◆ Bend the panel back and forth until it breaks. ◆ Panel should break on either side of the main weld, with reinforcement remaining attached to one or both sides of main weld area.

Presentation Outline	Steps to Cover/Key Points to Make
	Plug weld destructive test: • Place panel in a vise, with the jaws just below the plug welds. • Break the plug weld using a hammer or chisel. • This should create a hole that has a slightly torn look around the edges. Resistance spot weld destructive test: • Place two strips of metal at right angles to each other, and weld them together using a resistance spot welder. • Apply force, moving both pieces toward one another until the weld breaks. • Weld should have a very distinct round hole in the surface of one panel.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover metallurgy, molecular structure of metal (prior to and after welding), and destructive testing used by engineers in high-tech labs. The applied mathematics teacher could explain pounds per square inch (psi), force, and measurement of force.

Review:

Ask students review questions such as the following:

1. Why is it important to create test pieces and perform destructive tests?
2. What are the characteristics of a quality weld when performing destructive tests?

Application:

1. Have students create test pieces and perform destructive tests on the various types of welds.
2. Allow students to remove sections of welded areas from vehicles to be scrapped from program and then perform destructive tests on the factory welds.
3. Have students compare the results from their destructive tests on factory and non-factory welds.

Evaluation:

√ The student will perform destructive tests on each weld type. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.15/ 2.5.15.

Competencies 1.4.15/2.5.15: Perform destructive tests on each weld type

Performance Checklist

In performing destructive tests on each weld type, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Performed each weld on practice panel	☐	☐	☐	☐	☐
4. Mounted panel correctly in vise	☐	☐	☐	☐	☐
5. Performed correct destructive test in accordance with standard testing procedure	☐	☐	☐	☐	☐
6. Accurately identified all weld failures	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name ____ Date ______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.16/2.5.16:	Identify the causes of spits and sputters, burn through, lack of penetration, porosity, incomplete fusion, excessive spatter, distortion, and waviness of bead; make necessary adjustments
Competencies 1.4.17/2.5.17:	Identify cause of contact tip burn-back and failure of wire to feed; make necessary adjustments

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Identify causes of welding problems, and make necessary adjustments
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.16/2.5.16 & 1.4.17/2.5.17

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when identifying causes of welding problems and making necessary adjustments. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Many problems that occur during MIG welding are due to operator error (e.g., improper setup or operation of the welding machine).
2. These problems must be diagnosed and corrected because they will produce poor weld quality—which, in turn, can lead to weld failure.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Spits and Sputters	2. Spits and sputters create an inconsistent welding sound and leave rough deposits on the base material. Possible causes: • Wire speed and/or voltage setting need adjustment. **Key Point:** If the voltage/wire-speed ratio is correct, you will hear an even, high-pitched, buzzing sound. This sound has often been compared to that of bacon frying in a pan. • Gas cylinder valve is not fully open, or flow meter is improperly adjusted. Check manufacturer's specifications, and make necessary adjustments.
3. Burn-Through	3. With burn-through, holes appear in weld joint or base material. Possible causes: • Voltage is too high. • Gun travel speed is too slow. • Gun to base distance is too close. • There is an excessive gap between welding surfaces. Check one item at a time, and adjust as necessary.

Presentation Outline	Steps to Cover/Key Points to Make
4. Lack of Penetration	4. Lack of penetration is caused by insufficient deposit of filler material, which does not penetrate weld joint completely. Possible causes: • Voltage is too low. • Gun travel speed is too fast. • Wire speed needs adjustment. **Note:** Wire speed needs to be in correct ratio with voltage (see Step 2). Check one item at a time, and adjust as necessary.
5. Porosity	5. Porosity refers to holes or pits in the weld bead caused by trapped gas. Possible causes: • Flow meter setting is incorrect. • There is rust or other contaminants in the weld area. • Electrode wire is the wrong size. • Weld joint surface is not clean. Check one item at a time, and adjust or clean as necessary.
6. Incomplete Fusion	6. In incomplete fusion, the weld joint is not fused evenly on both sides of base material. Possible causes: • There is dirt, rust, or other contaminants in the weld surface area. • Voltage setting is incorrect. • Wire speed is incorrect. Check one item at a time, and adjust or clean as necessary.

Presentation Outline	Steps to Cover/Key Points to Make
7. Excessive Spatter	7. Excessive spatter refers to speckles or bumps of molten metal on sides of weld joint. Possible causes: • Gas is off, or valve is not fully open. • Flow meter setting is incorrect. • Voltage is too high. • Arc length is excessive. • Gun angle is incorrect. Gas cylinder valve must be fully open. Check remaining items one at a time.
8. Distortion in Weld Joint	8. Distortion in the weld joint means that the joint is uneven or the base material is warped. Possible causes: • There is an excessive gap between welding surfaces. • Voltage setting is too high. • Improper clamping or fastening methods were used. • There were not enough tack welds to hold metal in position prior to welding. **Key Point:** It is imperative that the base material be clamped, fastened, or tack-welded together to prevent the weld surface area from moving or separating. Check one item at a time, and adjust as necessary.

Presentation Outline	Steps to Cover/Key Points to Make
9. Waviness of Bead	9. A bead is "wavy" if it is not uniform in width. Possible causes: • Gun is not adequately controlled. **Key Point:** Gun control and movement will directly affect weld quality. • View of the weld puddle is obscured. **Key Point:** A clear view of the weld puddle is necessary to prevent *blind welding*, a condition in which the operator cannot see the weld surface area. Check one item at a time, and adjust as necessary.
10. Tip Burn-Back	10. Tip burn-back occurs when the electrode wire melts or sticks to gun tip. Possible causes: • Voltage setting is too high. • Wire speed is too slow. • Tip is dirty or needs to be replaced due to wear. • Tip-to-nozzle alignment is out of adjustment. • Tip or wire size is incorrect. Check one item at a time, and adjust, clean, or repair as necessary. **Key Point:** Make sure tip and wire size match (e.g., .023 tip and .023 wire).

Presentation Outline	Steps to Cover/Key Points to Make
11. Wire-Feed Failure	11. Wire-feed failure occurs when the electrode wire is not fed through welding gun cable properly. Possible causes: • Contact tip is burned back (see Step 10). • Gun cable or lines are defective or kinked. • There is dirt on guide rollers. • Guide roller is defective or worn out. • Tension on guide rollers is incorrect. • Tip and wire size don't match (see Step 10). • Wire-feed motor or switch is defective. • Electrode wire is dirty or contaminated (e.g., with rust, grease, oil). Check one item at a time, and adjust or clean as necessary. **Key Point:** Proper care, handling, and preventive maintenance will extend the life of welder parts. However, parts will eventually wear and need replacement. Deal with only those parts that can be repaired/replaced in the lab or shop area. Leave all other repairs to qualified repair personnel.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover metallurgy, inert and active welding gases, and electrical principles (e.g., polarity; AC/DC electrical currents; and amperage, voltage, flow, and resistance in electrical currents/circuitry). The applied mathematics teacher could work with students in measuring wire size, tip size, voltage, and amperage.

Review:

Ask students review questions such as the following:

1. What is the main cause of poor weld quality?
2. How do voltage and wire speed affect MIG welding?
3. Why should the gas valve be fully open?
4. Why is it necessary to remove contaminants (rust, dirt, grease) from the weld area?

Application:

1. Provide students with actual examples of weld problems created on a practice panel, and ask them to explain the possible cause of each problem.
2. For each problem shown in Activity 1, ask students to explain what effect the problem would have on the repair.

Evaluation:

√ The student will identify causes of welding problems and make necessary adjustments. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.16/2.5.16 & 1.4.17/2.5.17.

Competencies 1.4.16/2.5.16: Identify the causes of spits and sputters, burn through, lack of penetration, porosity, incomplete fusion, excessive spatter, distortion, and waviness of bead; make necessary adjustments

Competencies 1.4.17/2.5.17: Identify cause of contact tip burn-back and failure of wire to feed; make necessary adjustments

Performance Checklist

In identifying causes of welding problems and making necessary adjustments, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly identified the exact nature of the problem (spits and sputters, burn-through, etc.)	☐	☐	☐	☐	☐
4. Correctly identified the cause(s) of the problem	☐	☐	☐	☐	☐
5. Corrected each condition in accordance with established procedures	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.1: Preparation

Competency 2.1.2:	Inspect, remove, store, and replace exterior trim and moldings
Competency 2.1.4:	Inspect, remove, and replace non-structural body panels and components that may interfere with or be damaged during repair
Competency 2.1.6:	Protect panels and parts adjacent to repair area
Competency 2.1.7:	Remove dirt, grease, and wax from those areas to be repaired
Competency 2.1.8:	Remove corrosion protection, undercoatings, sealers, and other protective coatings necessary to perform repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Prepare a vehicle for non-structural repair
Criteria:	In accordance with the criteria in the checklist for Competencies 2.1.2/2.1.4/ 2.1.6/2.1.7/2.1.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when preparing vehicles for non-structural repair in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. When a customer brings in a damaged car for repair, it is important not to add to that damage. Items that interfere with the repair job must be carefully removed. Undamaged areas adjacent to the repair area must be protected.
2. Another preparation task is to remove contaminants and protective coatings that could affect repairs.
3. Remember, if you cause damage to undamaged panels/parts or leave contaminants on the surface that may ruin the paint job done later, this ultimately will result in a loss of time and money for the collision repair facility.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Removing Exterior Trim and Moldings	2. Inspect trim and moldings in order to— • verify damage listed on repair order; • identify damage not listed on repair order; and • identify whether there is a possibility that trim and moldings will be damaged during their removal. **Note:** Some molding/trim is part of a larger unit and cannot be removed without damaging the larger unit. Carefully remove trim and moldings: • Trim/molding can be attached with various types of fasteners (adhesive, clips, screws, etc.). • Check manufacturer's repair manuals to determine recommended or required removal and replacement process. Inspect trim/molding that was undamaged to ensure it was not damaged in the removal process. Store trim/molding in safe place where it can't be damaged (e.g., stepped on, driven over). **Key Point:** Any damaged trim/molding not noted on the repair order needs to be— • reported to shop manager/instructor to determine whether it should be replaced; and • ordered if necessary.

Presentation Outline	Steps to Cover/Key Points to Make
3. Removing Components That May Interfere or Be Damaged During Repair	3. Inspect components for same purposes as for trim/molding. Identify components that must be removed. If ***hoods***, for example, you may need to remove the following: • Windshield washer hoses and nozzles • Under-hood lamps • Insulation If ***deck/trunk lids***, you may need to remove the following: • Tail lamp assemblies • License plate lamps • Finish panels • Lock cylinder and latch assemblies If ***front fenders***, you may need to remove the following: • Front bumper assemblies • Head lamp assemblies • Marker lamp assemblies • Splash shields • Header panels If ***quarter panels***, you may need to remove the following: • Rear bumper assemblies • Tail lamp assemblies • Marker lamp assemblies • Glass • Door strikers • Fuel doors • Rear seats • Seat belts If ***doors***, you may need to remove the following: • Trim panels (inner door panels) • Door locks (inside and out) • Glass Remove all components carefully, using appropriate tools and manufacturer's procedures.

Presentation Outline	Steps to Cover/Key Points to Make
4. Protecting Areas Adjacent to Repair Area	4. If repair is to be made to panel or panel assembly while on vehicle, adjacent areas must be protected. The repair process (grinding, sanding, welding, drilling, applying sealant, using metal conditioners, etc.) can damage paint, glass, interior trims, carpet, and so on. Protection methods: • If repairing a door or hood or trunk/deck lid, you may be able to prop open the component to get it safely away from adjacent areas. • If not, can protect adjacent areas by covering with several layers of masking tape, masking paper, or plastic; or by using a piece of cardboard (e.g., placed between panels in the fender/door gap). • To protect against welding or grinding operations, use a fireproof blanket to cover glass, seats, panels, etc.
5. Removing Dirt, Grease, and Wax	5. Area to be repaired must be cleaned because contaminants left on the surface can cause problems later. For example, grinding and sanding can embed contaminants into sand scratches, which can eventually ruin a new paint job. Before attempting any repairs, first thoroughly wash the area with warm, soapy water. This will remove surface dirt. Then, clean with a wax and grease remover. **Key Point:** When using wax and grease removers, wear vinyl gloves and safety glasses.

Presentation Outline	Steps to Cover/Key Points to Make
6. Removing Protective Coatings	6. There are four general types of protective coatings: undercoatings, sealers, corrosion protection, and stone or gravel guard. Undercoating: • Found on wheel wells and underbodies • Protects surface from weather and minor impact (e.g., stones) • Must be removed if it is cracked or if it will get in the way of the repair process (e.g., is preventing access to a bolt or will be exposed to heat) • Remove by scraping off with a knife (e.g., putty knife) Sealer: • Found on seams • Provides a weather and vapor barrier • Remove by cutting out as much as possible with a knife (e.g., utility knife), and then grinding and/or sanding off the remainder • **Key Point:** If you do not remove the bulk of the sealer before grinding, the heat of the grinder can make removal more difficult. Heat increases the sealer's adhesive qualities, and it can quickly clog the sanding/grinding disks. Corrosion protection: • Found on every steel panel in a vehicle • Is not removed during preparation; it will be removed as result of repair process (e.g., grinding, sanding, chemical washes) and will need to be replaced during repair Stone or gravel guard: • Found on lower exterior body panels • Protects body from rock and stone chips • Comes in spray form or in self-adhesive clear sheets • Remove and replace as repair warrants

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons demonstrating why a soap-and-water solution works best for removing some contaminants (e.g., bird droppings), whereas higher-priced, sophisticated cleaners don't do nearly as well. He or she could also cover the properties of polymer emulsions (like sealers) that allow them to be firm to the touch yet remain flexible (i.e., how molecules link to one another in a polymer). The applied mathematics teacher could discuss ratios and how they apply to the mixing of chemicals.

Review:

Ask students review questions such as the following:

1. Why do you need to clean a part that's just going to get dirty again during the repair process?
2. What basic things must be removed prior to the repair job, and why?

Application:

1. Provide students with a variety of makes and models of cars, and have them identify and list the various components (e.g., miscellaneous assemblies, related hardware, moldings, name plates) that must be removed before removing each of the following: hood, deck/trunk, fender, quarter panel, and door.
2. As students practice preparing vehicles for non-structural repair, quiz them individually on the process (e.g., ask them what adjacent areas needed to be protected, and how).

Evaluation:

√ The student will prepare a vehicle for non-structural repair. His/her performance will be evaluated using a copy of the performance checklist for Competencies 2.1.2/2.1.4/ 2.1.6/2.1.7/2.1.8.

Competency 2.1.2:	Inspect, remove, store, and replace exterior trim and moldings
Competency 2.1.4:	Inspect, remove, and replace non-structural body panels and components that may interfere with or be damaged during repair
Competency 2.1.6:	Protect panels and parts adjacent to repair area
Competency 2.1.7:	Remove dirt, grease, and wax from those areas to be repaired
Competency 2.1.8:	Remove corrosion protection, undercoatings, sealers, and other protective coatings necessary to perform repairs

Performance Checklist

In preparing a vehicle for non-structural repair, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Inspected trim, molding, and other components for damage (and potential for damage)	☐	☐	☐	☐	☐
4. Removed trim/molding carefully	☐	☐	☐	☐	☐
5. Stored trim/molding in safe place	☐	☐	☐	☐	☐
6. Identified all components that could interfere with, or be damaged during, repair	☐	☐	☐	☐	☐
7. Removed identified components carefully in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Adequately protected areas adjacent to repair	☐	☐	☐	☐	☐
9. Washed damaged area thoroughly with warm, soapy water	☐	☐	☐	☐	☐
10. Removed other contaminants completely using wax and tar remover	☐	☐	☐	☐	☐
11. Identified areas of protective coating that needed to be removed	☐	☐	☐	☐	☐
12. Removed protective coatings using procedure appropriate for each type of coating	☐	☐	☐	☐	☐
13. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.2: Outer Body Panel Repairs, Replacements, and Adjustments

Competency 2.2.1: Determine the extent of direct and indirect damage and direction of impact; develop repair plan

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Determine the extent of direct and indirect damage and direction of impact, and develop a repair plan
Criteria:	In accordance with the criteria in the checklist for Competency 2.2.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when determining the extent of direct and indirect damage and direction of impact and developing repair plans. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Importance of assessing vehicle damage:
    - Expense of finding damage after repairs have been started or after painting has been finished (e.g., downtime, labor hours)
    - Possibility of causing additional damage by failing to note all indirect damage
2. Challenge of becoming a skilled inspector; it comes with experience!
3. Customers tend to underestimate damage or fail to recognize full extent of damage. Thus, the auto collision technician ***must*** get full picture before saying how long it will take—or it's out of pocket.

References:

Service manuals; technical service bulletins (TSBs); I-CAR zone procedure for use in developing repair plan. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8) Preparing estimates (6.9)
2. Reviewing Repair Order	2. Repair order authorizes work to be done. Review repair order to identify— • Tasks to be done • Time allowed **Note:** As you verify the nature and extent of damage, you may identify the need for additional work not authorized on repair order. This new work will need to be authorized, but it's best to wait until you are sure of everything that will need to be done. Make one phone call for authorization, not a separate one for each discovery.
3. Verifying Nature and Extent of Damage	3. First, make sure you're checking out the right car! Identify point of impact in order to determine starting point of inspection. That's direct damage. Determine direction of impact (e.g., check for scrapes, buckling, movement, misalignment). Identify extent of indirect damage using direction of impact as a basis.

Presentation Outline	Steps to Cover/Key Points to Make
4. Developing Repair Plan	4. Determine what you have to do. Determine most efficient and/or most logical order in which to do it. Determine whether you've got the right parts for the car or they will need to be ordered. **Note:** Use I-CAR zone technique to assess damage and develop repair plan. **General Rule of Thumb:** First damage in is last damage out!

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied science teacher could provide lessons on the principles of force and applied pressure, how direction affects force, and the difference between direct and indirect impact. The applied mathematics teacher could help students understand pounds per square inch (psi)—what it means and how it is measured.

Review:

Ask students review questions such as the following:

1. What is direct damage?
2. What is indirect damage?
3. In what order should you correct direct and indirect damage, and why?

Application:

1. Provide students with a panel with minor damage (e.g., door ding). Ask them—as a group—to identify the point of impact and any indirect damage and then briefly describe how they would repair it (repair plan).

2. Provide students with an accident vehicle. Ask them—individually—to identify the point of impact and any indirect damage and then briefly describe how they would repair it (repair plan). Have them compare their findings and their repair plans and discuss possible consequences of their individual findings/plans (what would happen if—).

Evaluation:

√ The student will determine the extent of direct and indirect damage and direction of impact and will develop a repair plan. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.2.1.

Competency 2.2.1: Determine the extent of direct and indirect damage and direction of impact, and develop a repair plan

Performance Checklist

In determining the extent of direct and indirect damage and direction of impact and developing a repair plan, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly interpreted the repair order	☐	☐	☐	☐	☐
4. Accurately identified the point of impact	☐	☐	☐	☐	☐
5. Identified all direct damage	☐	☐	☐	☐	☐
6. Identified any and all indirect damage	☐	☐	☐	☐	☐
7. Prepared a repair plan that was—					
a. Appropriate based on extent and direction of impact	☐	☐	☐	☐	☐
b. Consistent with the terms of the repair order	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.2: Outer Body Panel Repairs, Replacements, and Adjustments

Competency 2.2.2:	Inspect, remove, and replace bolted, [bonded, and welded] steel panel or panel assemblies
Competency 2.2.4:	Inspect, remove, replace, and align hood, hood hinges, and hood latch
Competency 2.2.5:	Inspect, remove, replace, and align deck lid, lid hinges, and lid latch
Competency 2.2.7:	Inspect, remove, replace, and align bumper bars, covers, reinforcement guards, isolators, and mounting hardware

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Inspect, remove, replace, and align ***bolted*** steel panels or panel assemblies (e.g., hood, deck lid, bumper assembly) and related hardware (e.g., hood/lid hinges, hood/lid latches)

Criteria: In accordance with the criteria in the checklist for Competencies 2.2.2/2.2.4/2.2.5/2.2.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, removing, replacing, and aligning bolted steel panels or panel assemblies and related hardware in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. All vehicles have panels that use a variety of fasteners (usually bolts) that hold them in place.
2. Reasons why panels are bolted on:
    - They are not structural panels, and therefore bolting is acceptable and easy.
    - They are frequently damaged in accidents, and bolting makes replacement less difficult.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Examples of Bolted Panels and Panel Assemblies	2. Hoods Decks lids Fenders Bumper and fascia assemblies Doors Lift gates
3. Removing Bolted Panels	3. Prepare vehicle for repair (2.1): ◆ Disconnect and remove miscellaneous assemblies (e.g., lights, wiring, trim) that prevent the removal of the panel. ◆ Remove any related hardware, moldings, and name plates. **Key Point:** Look for signs of damage (e.g., buckles on inner panels and lack of alignment with adjacent panels) before panel removal. Select appropriate tools for panel to be removed. Remove all fasteners. Remove panel. **Key Point:** Never discard old panel until all repairs have been completed. Some parts from the old panel may need to be reused.

Presentation Outline	Steps to Cover/Key Points to Make
4. Replacing Bolted Panels	4. Set new panel temporarily in place. Inspect for fit and alignment. Align panel as necessary (2.2.8). Bolt new panel in place (hand-tight). Restore any sealers and sound deadeners (2.2.16). Once new panel has been painted, you can reinstall related hardware, moldings, name plates, and miscellaneous assemblies.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can cover the relative strength of different mounting methods—welding, bolting, bonding—and the effect of torque on fasteners made of different materials (e.g., plastic, steel). The applied mathematics teacher could provide lessons on metric and English measures in relation to sockets and thread size.

Review:

Ask students review questions such as the following:

1. What are the general reasons why panels are bolted on rather than bonded or welded?
2. Why is it so crucial to inspect the body lines ***before*** removing the panel?

Application:

1. Provide students with a variety of the typical fasteners used on vehicles, and have them identify the correct removal tool for each.
2. As students practice inspecting, removing, replacing, and aligning bolted steel panels or panel assemblies and related hardware, quiz them individually on the process (e.g., ask them to point out signs of damage and how they located them).

Evaluation:

√ The student will inspect, remove, replace, and align bolted steel panels or panel assemblies and related hardware. His/her performance will be evaluated using a copy of the performance checklist for Competencies 2.2.2/2.2.4/2.2.5/2.2.7.

Competency 2.2.2:	Inspect, remove, and replace bolted, [bonded, and welded] steel panel or panel assemblies
Competency 2.2.4:	Inspect, remove, replace, and align hood, hood hinges, and hood latch
Competency 2.2.5:	Inspect, remove, replace, and align deck lid, lid hinges, and lid latch
Competency 2.2.7:	Inspect, remove, replace, and align bumper bars, covers, reinforcement guards, isolators, and mounting hardware

Performance Checklist

In inspecting, removing, replacing, and aligning bolted steel panels or panel assemblies and related hardware, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Disconnected and removed miscellaneous assemblies, related hardware, moldings, and name plates	☐	☐	☐	☐	☐
3. Identified any signs of damage that would affect alignment	☐	☐	☐	☐	☐
4. Selected tools appropriate for fasteners to be removed	☐	☐	☐	☐	☐
5. Removed fasteners	☐	☐	☐	☐	☐
6. Removed panel	☐	☐	☐	☐	☐
7. Set new panel temporarily in place and inspected for fit and alignment	☐	☐	☐	☐	☐
8. Aligned panel as necessary	☐	☐	☐	☐	☐
9. Fastened new panel in place hand-tight	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.2: Outer Body Panel Repairs, Replacements, and Adjustments

Competency 2.2.2:	Inspect, remove, and replace [bolted], bonded, [and welded] steel panel or panel assemblies
Competency 2.2.6:	Inspect, remove, replace, and align doors, tailgates, hatches, lift gates, latches, hinges, and related hardware

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, remove, replace, and align ***bonded*** steel panels or panel assemblies (e.g., door outer panels, roof panels) and related hardware (e.g., latches, hinges)
Criteria:	In accordance with the criteria in the checklist for Competencies 2.2.2/2.2.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, removing, replacing, and aligning bonded steel panels or panel assemblies and related hardware in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Some panels are mounted by bonding. Generally this method provides a strong and quiet assembly (no squeaks).

2. Most bonded panels are cosmetic in nature (e.g., outer panels of roof or doors) and have little or no structural value. Therefore, bonding is a great alternative to welding in terms of cost and time savings.

3. It is crucial to use the mounting method specified by the manufacturer because if, for example, you weld on a panel that is supposed to be bonded (or vice versa), the warranty will be voided.

4. Bonded metal panels are often reinforced with tack welds.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Examples of Bonded Panels	2. Door outer panel Tailgates Hatches Lift gates Fenders Roofs **Note:** Panels may be made of metal or some type of plastic/fiberglass.
3. Removing Bonded Panels	3. Prepare vehicle for repair (2.1): • Disconnect and remove any hardware and assemblies that prevent removal of panel. • For example: latches, door handles, inner door panels, windows, mirrors, speakers, electrical components Identify vehicle manufacturer's guidelines for panel replacement. Select appropriate tool (e.g., grinder, cutting tool, heat) to remove panel. Remove panel assembly, following all manufacturer's guidelines and all safety practices for tools involved.

Presentation Outline	Steps to Cover/Key Points to Make
4. Replacing Bonded Panels	4. Inspect surface onto which the new panel will be mounted in order to ensure that the new panel will fit properly. Inspect mounting surface for damage: • Cracked paint • Cracked seam sealers • Buckles and breaks in mounting surface that may need repair Make any needed repairs. Set new panel temporarily in place. Inspect for fit and alignment. Align panel as necessary (2.2.8). Clean inner panel as needed to remove old bonding materials, rust, paint (2.2.11). Apply corrosion protection to area if required (2.2.11). Restore any sound deadeners (2.2.16). Apply bonding material evenly to all edges of panel. **Key Point:** Need to make any final minor adjustments to panel immediately because bonding material sets quickly. Set panel in place. Apply seam sealer, if required, to prevent corrosion problems. Once new panel has been painted, you can reinstall related hardware and assemblies.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can cover the relative strength of different mounting methods—welding, bolting, bonding; characteristics of today's bonding materials; effect of grinding on bonding material (e.g., heat can cause chemical changes, fumes); differences between mechanical and chemical bonding; and how corrosion protection works and how it affects different kinds of bonding. The applied mathematics teacher could work with students in calculating amount of bonding material needed for a given surface (i.e., how to measure surface area).

Review:

Ask students review questions such as the following:

1. What qualities of bonding materials make them an attractive alternative to bolting and welding for some panels?
2. When is bonding not a feasible option?
3. What safety precautions must be taken when using welding equipment around bonding materials?

Application:

1. Provide practice flanges (e.g., used doors), and have students practice using grinder just to remove panel edges—grinding neither too little nor too much.
2. As students practice inspecting, removing, replacing, and aligning bonded steel panels or panel assemblies, quiz them individually on the process (e.g., ask them to point out signs of damage that need to be repaired).

Evaluation:

√ The student will inspect, remove, replace, and align bonded steel panels or panel assemblies and related hardware. His/her performance will be evaluated using a copy of the performance checklist for Competencies 2.2.2/2.2.6.

Competency 2.2.2: Inspect, remove, and replace [bolted], bonded, [and welded] steel panel or panel assemblies

Competency 2.2.6: Inspect, remove, replace, and align doors, tailgates, hatches, lift gates, latches, hinges, and related hardware

Performance Checklist

In inspecting, removing, replacing, and aligning bonded steel panels or panel assemblies and related hardware, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Disconnected and removed hardware and assemblies	☐	☐	☐	☐	☐
4. Removed panel assembly	☐	☐	☐	☐	☐
5. Accurately cut and removed panel edges	☐	☐	☐	☐	☐
6. Removed exposed flange if required	☐	☐	☐	☐	☐
7. Removed outer panel	☐	☐	☐	☐	☐
8. Identified any signs of damage that would affect alignment	☐	☐	☐	☐	☐
9. Accurately identified needed repairs	☐	☐	☐	☐	☐
10. Made all needed repairs	☐	☐	☐	☐	☐
11. Set new panel temporarily in place and inspected for fit and alignment	☐	☐	☐	☐	☐
12. Cleaned inner panel as needed	☐	☐	☐	☐	☐
13. Applied corrosion protection if required	☐	☐	☐	☐	☐
14. Applied bonding material evenly to all edges of panel	☐	☐	☐	☐	☐
15. Set panel in place and made any final alignment adjustments	☐	☐	☐	☐	☐
16. Folded flanges using flanging tool if required	☐	☐	☐	☐	☐
17. Applied seam sealer smoothly and with full coverage	☐	☐	☐	☐	☐
18. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.2: Outer Body Panel Repairs, Replacements, and Adjustments

Competency 2.2.2:	Inspect, remove, and replace [bolted, bonded, and] welded steel panel or panel assemblies
Competency 2.2.12:	Cut out damaged sections of sheet steel body panels and weld in replacements according to vehicle and industry specifications

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, remove, replace, and align ***welded*** steel panels or panel assemblies
Criteria:	In accordance with the criteria in the checklist for Competencies 2.2.2/2.2.12

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, removing, replacing, and aligning welded steel panels or panel assemblies in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Some panels are welded on. Generally this is done in areas where the integrity of the car is crucial and must meet specifications. For example, if a car rolls, the roof must provide the necessary protection. "Integrity" refers to the structural strength of the vehicle.

2. To preserve the structural integrity of the vehicle and any vehicle warranties, be sure to refer to materials from the manufacturer, I-CAR, and TECHCOR for methods to use in replacing welded panels.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Examples of Welded Panels	2. Quarter panels (e.g., rear fender) Rear body panels Roof Rocker panels Door outer panels
3. Removing Welded Panels or Panel Sections	3. Prepare vehicle for repair (2.1). Determine where cut should be made in order to replace damaged area ***and*** maintain structural integrity. Remove inner panels, trim, and hardware as necessary. Inspect factory welds for damage. This will alert you to any indirect damage to the surface to which new panel will be mounted. Determine need for repairs. Remove welds (e.g., drill, spot weld cutter). Measure and mark old panel as determined. Cut panel as marked (1.4.2/2.5.2).

Presentation Outline	Steps to Cover/Key Points to Make
4. Replacing Welded Panels	4. Measure and mark new panel using sectioning process. Cut panel as marked. **Key Point:** You may only get one chance to make the right cut on a new panel. If you cut it too short, you've ruined the panel. Mount new panel, and check its alignment. MIG-weld panel in place using appropriate welds (1.4.2/2.5.2 & 1.4.14/2.5.14). **Key Point:** Duplicate original factory welds (process used, type of joint, number of welds, etc.).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the science of welding, the relative strength of different welding methods, and molecular structure and how different types of welds affect it. The applied mathematics teacher could help student in measuring panel replacement using ***both*** metric and standard measures.

Review:

Ask students review questions such as the following:

1. When checking factory spot welds, what should you be looking for?
2. How does the sectioning process contribute to the maintenance of the vehicle's structural integrity?

Application:

1. Provide students with illustrations of vehicles with damage on different types of welded panels, and ask them to work individually to identify where the cut should be made on each vehicle. Then have them compare results and justify their decisions.
2. As students practice measuring and marking panels, quiz them individually on the process (e.g., ask them to describe how they determined where to measure from and to).

Evaluation:

- √ The student will inspect, remove, replace, and align welded steel panels or panel assemblies. His/her performance will be evaluated using a copy of the performance checklist for Competencies 2.2.2/2.2.12.

Competency 2.2.2: Inspect, remove, and replace [bolted, bonded, and] welded steel panel or panel assemblies

Competency 2.2.12: Cut out damaged sections of sheet steel body panels and weld in replacements according to vehicle and industry specifications

Performance Checklist

In inspecting, removing, replacing, and aligning welded steel panels or panel assemblies, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly determined where cut should be made	☐	☐	☐	☐	☐
4. Inspected factory welds to identify any indirect damage to mounting surface	☐	☐	☐	☐	☐
5. Made needed repairs to mounting surface	☐	☐	☐	☐	☐
6. Accurately measured and marked old panel for cutting	☐	☐	☐	☐	☐
7. Cut old panel as marked	☐	☐	☐	☐	☐
8. Accurately measured and marked new panel using sectioning process	☐	☐	☐	☐	☐
9. Cut new panel as marked	☐	☐	☐	☐	☐
10. Mounted and accurately aligned new panel	☐	☐	☐	☐	☐
11. MIG-welded panel securely using appropriate welds	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.2: Outer Body Panel Repairs, Replacements, and Adjustments

Competency 2.2.8: Check and align fenders, headers, and other panels

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check and align fenders, headers, and other panels
Criteria:	In accordance with the criteria in the checklist for Competency 2.2.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking and aligning fenders, headers, and other panels in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Checking and aligning fenders, headers, and other similar panels involves only small alignment shifts in sheet metal (not in the frame).
2. Discuss purposes of front fenders, headers, and other panels.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Checking Alignment	2. Visually check alignment to determine what adjustment is needed to line fender and header up with hood.
3. Aligning Front Fenders and Headers	3. Loosen all bolts on front fenders and headers. Adjust as needed for alignment. Begin to tighten bolts. Methods for rechecking alignment: • Check alignment visually. • Measure from point to point in engine compartment using tram gauge, and check both readings against manufacturer's specifications. If front fenders and headers are still not aligned, loosen bolts and adjust panels again. Recheck alignment. Repeat process until panels are aligned. Tighten bolts to manufacturer's specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can work with students on securing accurate measurements, interpreting measurements taken using tram gauge, and using standard and metric measurements.

Review:

Ask students review questions such as the following:

1. True or False: If you measure point to point in both directions and both measurements are identical, the panels are aligned.
2. Define symmetrical and asymmetrical measurements.

Application:

1. Provide students with a list of particular vehicle makes, models, years; and ask them to locate the under-hood dimensions for each vehicle in the appropriate manual.
2. Provide students with vehicles with front fenders and headers that are out of alignment, and have them check alignment using a tram gauge.
3. As students practice restoring alignment, quiz them individually on the process (e.g., ask them to explain how to check alignment visually).

Evaluation:

√ The student will check and align fenders, headers, and other panels. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.2.8.

Competency 2.2.8: Check and align fenders, headers, and other panels

Performance Checklist

In checking and aligning fenders, headers, and other panels, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Visually determined amount of adjustment needed to align front fender and header	☐	☐	☐	☐	☐
4. Loosened all bolts on front fender and header	☐	☐	☐	☐	☐
5. Adjusted as needed for alignment	☐	☐	☐	☐	☐
6. Began to tighten bolts	☐	☐	☐	☐	☐
7. Rechecked alignment visually or using tram gauge	☐	☐	☐	☐	☐
8. Checked tram gauge readings against manufacturer's specifications	☐	☐	☐	☐	☐
9. Repeated process (4--8), if necessary, until front fender and header were accurately aligned	☐	☐	☐	☐	☐
10. Tightened bolts to manufacturer's specifications	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunits 2.2/2.3: Outer Body Panel Repairs, Replacements, and Adjustments/
Metal Finishing and Body Filling

Competency 2.2.9:	Straighten and rough-out contours of damaged panel to a surface condition for body filling or metal finishing using power tools, hand tools, and stud welder
Competency 2.3.1:	Remove paint from the damaged area of a body panel
Competency 2.3.2:	Locate and reduce surface irregularities on a damaged body panel
Competency 2.3.3:	Demonstrate hammer and dolly techniques

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Straighten and rough-out contours and reduce surface irregularities on a damaged panel in preparation for body filling or metal finishing

Criteria: In accordance with the criteria in the checklist for Competencies 2.2.9/2.3.1/2.3.2/2.3.3

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when straightening and roughing-out contours and reducing surface irregularities on damaged panels in preparation for body filling or metal finishing. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Sometimes a damaged panel does not need to be replaced; the damage is such that it can be repaired.

2. When making repairs to a body panel, it is usually necessary to remove paints from damaged areas in preparation for applying body fillers or metal-finishing the repair.

3. The panel must be returned to within 1/4" of its original contour. This is important because fillers should never be applied over 1/4" thick. They tend to lose their flexibility when used in thick layers, which can cause the failure of both the filler as well as subsequent products applied over those thick filler layers.

4. It is critical to select the appropriate technique for repairing the damage. Using the right technique can speed up the repair process. Using the wrong technique can further damage the panel.

References:

Service manuals; technical service bulletins (TSBs); I-CAR and ASE metal straightening guidelines. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Selecting Proper Abrasive for Paint Removal	2. Identify type of metal. Use magnet if needed to test metal type. Select proper sanding or grinding disc abrasive for type of metal: • For steel, use 24- or 36-grit. • For aluminum, use 36- to 40-grit.
3. Removing Paint	3. Paint should be removed from the paint area and 3"–4" beyond the damage. Use an S-shaped motion, and do not stay in one area too long. Keep sander moving. **Key Point:** Use caution to avoid a buildup of heat and to remove as little as possible of the metal surface itself. It may be necessary to make multiple passes over area to be repaired. Inspect area for any remaining traces of paint and primers, and remove them. **Key Point:** Filler adheres best to a clean surface.

Presentation Outline	Steps to Cover/Key Points to Make
4. Assessing Damage to Panel	4. Assess extent of damage (e.g., minor surface irregularity, scrape, crease, major dents). Determine procedure needed to restore original contours (i.e., to raise or lower high and low spots): • Using hammer and dolly techniques • Welding pins into damaged area and using a dent puller • Drilling holes into damaged area and using a slide hammer or pull hooks • Using spoons or pry bars
5. Using Hammer and Dolly Techniques	5. Two methods: • *Hammer-on-dolly method*—used to stretch and smooth metal • *Hammer-off-dolly method*—used to straighten metal with a flat or low crown surface Surface of hammer and dolly should match the contour of the panel being repaired. Faces and surfaces of dollies and hammers should be clean and smooth. Hammer-on-dolly method: • Hold dolly with light pressure and allow it to rebound when struck with hammer. • The rebound effect stretches low or shrunken spots back to their original shape. Hammer-off-dolly method: • Hold dolly under low spots, and use hammer to tap down high spots.

Presentation Outline	Steps to Cover/Key Points to Make
6. Using Welded Pins and a Dent Puller	6. Use of pins gives you something to grip to pull out damage. The advantage of using pins over drilling holes is that it is always preferable not to drill holes. Determine how many pins should be used and where they should be placed. For example: • For a long scrape or crease, need to start at each end and work toward center. • For a dent, need to start on outside perimeter of damaged area and work to deepest part. Weld pins into damaged area. Attach dent puller to each pin and pull out. Cut or break off pins. Grind surface smooth.
7. Using Spoons and Pry Bars	7. Spoons can be used in place of a dolly to exert force over a larger area or to pry or lift damaged area. Pry bars are used to raise or lift damaged areas that are not accessible using a hammer or dolly. **Key Point:** Always start at shallowest part of dent and work toward center or deepest area.
8. Drilling Holes and Using a Slide Hammer or Pull Hooks	8. Drill holes in damaged area with power drill. Use pull hooks for minor damage. They provide a gentle pull. Use a slide hammer for more major damage. • Slide hammer has screw attached to end. • Screw into each hole and pull panel back into close-to-original contour.

Presentation Outline	Steps to Cover/Key Points to Make
9. Checking Results	9. Inspect surface for irregularities. Panel should be returned to within 1/8" of original contours. A straightedge can be used to check whether contours are within 1/8".

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could cover metallurgy terminology (hardening, annealing, elasticity). The applied science teacher could cover topics such as the following:

- Types of abrasive material used and where these materials are obtained (e.g., manufactured, mined)
- Effect of heat on painted and base metal surfaces; heat transfer rate of aluminum vs. steel
- Molecular structure of metals; disturbance of molecules in an accident and stress relief of metals; elasticity of metals (ability to return to original form)

Review:

Ask students review questions such as the following:

1. Why is it important to remove paint from damaged panels, and what grits are most commonly used?
2. What could happen if panels are not returned to their original contours before body filling?
3. What factors should you consider in trying to determine which method to use to restore the panel in preparation for filling?

Application:

1. Provide students with damaged body panels, and have them remove the paint using a variety of sanding and grinding discs. Then ask them to compare the rate of removal and depth of sand scratches left by different types of abrasives.
2. Provide students with practice panels with different amounts of damage, and have them identify the appropriate technique(s) to use to restore each area of damage.
3. Provide students with practice panels with different amounts of damage, and have them repair body panel damage to within 1/4" of original contours using appropriate technique for each area of damage. It is suggested that the panels be removed from vehicle so students can examine each technique from both sides of panel.

Evaluation:

√ The student will straighten and rough-out contours and reduce surface irregularities on a damaged panel in preparation for body filling or metal finishing. His/her performance will be evaluated using a copy of the performance checklist for Competencies 2.2.9/2.3.1/2.3.2/2.3.3.

Competency 2.2.9: Straighten and rough-out contours of damaged panel to a surface condition for body filling or metal finishing using power tools, hand tools, and study welder
Competency 2.3.1: Remove paint from the damaged area of a body panel
Competency 2.3.2: Locate and reduce surface irregularities on a damaged body panel
Competency 2.3.3: Demonstrate hammer and dolly techniques

Performance Checklist

In straightening and roughing-out contours and reducing surface irregularities on a damaged panel in preparation for body filling or metal finishing, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Accurately determined type of metal	☐	☐	☐	☐	☐
4. Selected correct type of abrasive for metal	☐	☐	☐	☐	☐
5. Removed paint completely from damaged area and 3"–4" beyond	☐	☐	☐	☐	☐
6. Accurately assessed damage to panel	☐	☐	☐	☐	☐
7. Determined appropriate method(s) to be used to restore panel to 1/4" of original contour	☐	☐	☐	☐	☐
8. Stretched and smoothed metal as needed using selected method(s)	☐	☐	☐	☐	☐
9. Raised low areas and lowered high spots as needed using selected method(s)	☐	☐	☐	☐	☐
10. Restored surface to within 1/4" of original contour	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.2: Outer Body Panel Repairs, Replacements, and Adjustments

Competency 2.2.10: Weld cracked or torn steel body panels; repair broken welds

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Weld cracked or torn steel body panels, and repair broken welds
Criteria:	In accordance with the criteria in the checklist for Competency 2.2.10

Introduction:

General Introductory Techniques: Share personal experiences you have had when welding cracked or torn steel body panels and repairing broken welds in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain why it is important to understand ***why*** a panel cracked or a weld broke.

2. Most common causes are vibration and stress.

3. Once you find the cause, then you need to correct it ***before*** you do any welding.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Identify and correct the situation that led to the problem (cracked or torn panel, broken weld, stress).
3. Welding Cracked Panels	3. Drill each end of the cracked area in order to stop further movement. Use a reinforced-butt weld to repair the crack (if possible). If back side is open— • Place metal at least 1" wide behind the crack. • Perform weld (1.4.2/2.5.2 & 1.4.14/ 2.5.14). If back side is enclosed (no way to place metal behind)— • Drill ends of crack. • Perform weld starting at one drill hole and welding to other. **Key Point:** Make sure drilled holes are completely filled. • Thin it. **Key Point:** Be sure not to over-grind.
4. Repairing Broken Welds	4. Remove damaged weld from weld joint. Be sure to start at just beyond where the break started. Perform weld (1.4.2/2.5.2 & 1.4.14/ 2.5.14).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can cover the effect of vibration on steel and the effect of stress on molecular structure and how, over a long period of time, the metal becomes brittle.

Review:

Ask students review questions such as the following:

1. What are the major causes of cracks and broken welds?
2. What are the differences between the procedure for repairing cracks and the procedure for repairing broken welds?

Application:

1. Provide pairs of students with a micrometer and a piece of metal no thicker than 24-gauge and at least 2' long, and have them perform the following steps:
   - Measure the thickness of the metal.
   - Stand at each end of the metal, bend it in half, and then bend it back and forth as quickly as possible until it breaks.
   - Remeasure the metal at the edge of the break.
   - List the possible causes of the differences in measurements.

Evaluation:

√ The student will weld cracked or torn steel body panels and repair broken welds. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.2.10.

Competency 2.2.10: Weld cracked or torn steel body panels; repair broken welds

Performance Checklist

In welding cracked or torn steel body panels and repairing broken welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Accurately identified situation causing the problem	☐	☐	☐	☐	☐
4. Corrected the problem situation in accordance with standard procedure	☐	☐	☐	☐	☐
5. Repaired cracked panel with the back side open in accordance with established procedure	☐	☐	☐	☐	☐
6. Repaired cracked panel with the back side enclosed in accordance with established procedure	☐	☐	☐	☐	☐
7. Repaired broken weld in accordance with established procedure	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.2: Outer Body Panel Repairs, Replacements, and Adjustments

Competency 2.2.11: Restore corrosion protection

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Restore corrosion protection
Criteria:	In accordance with the criteria in the checklist for Competency 2.2.11

Introduction:

General Introductory Techniques: Share personal experiences you have had when restoring corrosion protection in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Any time you cut, grind, sand, or drill into bare metal, you remove corrosion protection, which ***must*** be replaced (ASE, I-CAR, manufacturer's specifications).
2. New parts have factory-applied corrosion protection. Care must be taken not to remove that protection. If it is removed by mistake (e.g., a scratch), it must be replaced.
3. Failure to restore corrosion protection will void warranties and can result in the failure of repairs (e.g., welds, paint, fillers).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Types of Corrosion Protection	2. General types: • Zinc-enriched primers • Epoxy primers • Etching primers • Weld-thru primers • Seam sealers • Rust-proofing Which product should you use? Duplicate the corrosion protection process used by the manufacturer.
3. When to Apply	3. Apply after repairs. Before any paint goes on, the corrosion product must be applied first.
4. Preparing the Surface	4. Check surface for any existing rust, paint, dirt, undercoating. Grind, sand, or clean surface to remove all contaminants. Apply etching primer or wash surface with metal conditioner (sulfuric acid); brush on and wipe off. **Key Point:** This is an acid wash, so it is absolutely essential to wear eye protection and rubber gloves. Allow adequate time for surface to dry.

Presentation Outline	Steps to Cover/Key Points to Make
5. Applying Corrosion Protection	5. **Key Point:** Rubber gloves, eye protection, and respirator should be used when working with corrosion protection products. Apply primers to repair area: • Check pot life (length of time product is usable once mixed). **Key Point:** If pot life is short, do not mix more than you need or it will be wasted. • Mix the product in accordance with manufacturer's specifications. • Immediately fill paint gun with mixture. • Apply product (thickness, number of coats) in accordance with manufacturer's specifications. • Apply product so as to minimize waste. • Clean paint gun immediately after use. • Discard unused product in accordance with EPA standards. Apply seam sealers to areas (panel joints, seams, etc.) that will be exposed to the environment (2.2.16). Apply rust-proofing in accordance with manufacturer's specifications. – Failure to do so will void warranties (e.g., vehicle, paint products, parts).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can work with students on ratios, percentages, and measuring liquids accurately. He or she could also cover square feet so students have a better understanding of how much material is needed to do a job and how to calculate cost per square foot. The applied science teacher can cover the chemistry of mixing the components of the corrosion protection product (chemical reactions involved), the effects of different chemicals on metals, and how rust forms and its characteristics.

Review:

Ask students review questions such as the following:

1. Why must you use a metal conditioner to remove rust after you have already used a grinding and/or sanding process to remove the rust?

2. How does the pot life of the product affect how you use it?

Application:

1. Provide students with access to a variety of vehicles, and have them examine each to locate corrosion protection used. Ask them to note the type and location of each instance of corrosion protection found.

2. Have students apply different primers and metal conditioners to different practice panels, label each with the name of the product used, and then place the panels outside in an area where they are exposed to the environment. At different intervals (1 week, 2 weeks, 1 month, etc.), have students examine the panels and note the results.

Evaluation:

√ The student will restore corrosion protection. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.2.11.

Competency 2.2.11: Restore corrosion protection

Performance Checklist

In restoring corrosion protection, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Removed all contaminants by grinding or sanding	☐	☐	☐	☐	☐
4. Applied metal conditioner in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Allowed adequate drying time	☐	☐	☐	☐	☐
6. Applied corrosion protection in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
7. Ensured that good coverage was provided without waste of product	☐	☐	☐	☐	☐
8. Cleaned equipment immediately after use	☐	☐	☐	☐	☐
9. Discarded unused product in accordance with EPA standards	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name ______________________________ **Date** ______________

Competency 2.2.16: Restore sealers, mastic, sound deadeners, and foam fillers

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Restore sealers and sound deadeners
Criteria:	In accordance with the criteria in the checklist for Competency 2.2.16

Introduction:

General Introductory Techniques: Share personal experiences you have had when restoring sealers and sound deadeners in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Sealers are paste-like materials whose primary purpose is to provide a weather and vapor barrier—in other words, to keep moisture out. For example, doors are designed to let moisture from windows drain out at the bottom, but a sealer is needed to keep that moisture from entering the interior. Sealers also provide a good surface for painting.

2. Sound deadeners—as their name implies—are designed to minimize vehicle noise. They absorb vehicle-related noises such as vibration, and help keep external noises out. They also add strength to the total assembly under normal driving conditions. For example, with thinner-gauge metal, sound deadeners may be used to firm things up.

3. When specified by the manufacturer, sealers and sound deadeners must be restored when a panel has been repaired or replaced.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safety Practices	2. Gloves, glasses, and respirators must be used when working with these substances.
3. Sealers/Mastics	3. Sealers/mastics come in caulking-type tube for use in caulking gun. They hold body well—don't dry out to the point where they get dry and brittle.
4. Restoring Sealers/Mastics	4. Apply at seams using caulking gun. Smooth out the sealer/mastic if it's a seam that will be seen.
5. Sound Deadeners	5. Types of sound deadeners: • Adhesive-backed pad • Sprayed-in foam in aerosol container • Tar-like undercoating material in caulking tube or spray can
6. Restoring Sound Deadeners	6. During removal process, note the type and amount (size, area covered, etc.) of sound deadener that was provided by original equipment manufacturer (OEM). Before outer panel is mounted, apply sound deadeners in the type and amount originally provided by OEM. Apply in accordance with procedures specified by manufacturer of the particular type of sound deadener used.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could involve students in experiments on sound attenuation (e.g., beat on empty tin can; beat on same can filled with water). He or she could also discuss vapor barriers and the properties of polymer emulsions (like sealers) that allow them to be firm to the touch yet remain flexible (i.e., how molecules link to one another in a polymer).

Review:

Ask students review questions such as the following:

1. How does the use of a seam sealer prevent rust?
2. What do sound deadeners do besides deaden sound?

Application:

1. Provide students with a variety of used or donated panel assemblies, and have them identify the different types of sealers and sound deadeners that were used on them.
2. As students practice applying sealers and sound deadeners, quiz them individually on the process (e.g., ask them how they determined what type and amount to use).

Evaluation:

√ The student will restore sealers and sound deadeners. His/her performance will be evaluated using a copy of the performance checklist for Competency 2.2.16.

Competency 2.2.16: Restore sealers, mastic, sound deadeners, and foam fillers

Performance Checklist

In restoring sealers and sound deadeners, the student—

	1	**2**	**3**	**4**	**5**
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Applied sealers and sound deadeners in accordance with—					
a. Type and amount provided by OEM	☐	☐	☐	☐	☐
b. Procedures specified by manufacturer of type of sealer or sound deadener used	☐	☐	☐	☐	☐
4. Ensured that all products were neatly applied	☐	☐	☐	☐	☐
5. Ensured that no drain holes were plugged by product	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Unit 2: Non-Structural Analysis and Damage Repair

Subunit 2.3: Metal Finishing and Body Filling

Competency 2.3.6:	Mix body filler
Competency 2.3.7:	Apply body filler; cheese-grate during curing
Competency 2.3.8:	Rough sand cured body filler to contour; finish sand

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform body filling procedures
Criteria:	In accordance with the criteria in the checklist for Competencies 2.3.6–2.3.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when performing body filling procedures in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. If body filler is mixed improperly, there will be wasted material and the product may fail (lack of adhesion and product cracking). Such a repair will lack quality and professional craftsmanship.

2. If body filler is applied incorrectly (e.g., unclean spreader, uneven application), it will affect how much sanding is needed later to smooth the filler.

3. When filling and shaping larger areas, a cheese grater can be used to shape the filler.

4. Once body filler and cheese-grating have been used to approximate the rough shape of the original panel, a variety of sandpapers are used to rough- and final-sand the panel to its original shape and contour.

References:

Service manuals; technical service bulletins (TSBs); mixing instructions from different types of fillers; product information from sandpaper manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Necessary Materials	2. Filler and hardener Spreader—applicator or putty knife Mixing board—nonporous surface such as glass, metal, or plastic **Key Point:** Porous surfaces must not be used because they absorb the chemicals contained in body fillers. Rubber or vinyl gloves
3. Mixing Body Filler	3. Fillers have a tendency to separate or settle, so they need to be mixed just prior to use. **Key Point:** Follow label directions exactly. Place filler on mixing board. Add cream hardener after first kneading it. **Rule of Thumb:** Use 1" of hardener for each golf-ball-size of filler. Mix hardener and filler together using a spreader and a back-and-forth scraping motion. **Key Point:** Do not stir because that will create air bubbles, which will appear as pinholes in the cured filler. Mix until product is a uniform color, without streaks. **Key Point:** Streaks indicate improper mixing of filler.

Presentation Outline	Steps to Cover/Key Points to Make
4. Applying Body Filler	4. Apply filler to damaged panel using a clean spreader and a firm pressure. Apply in thin coats to prevent pinholes. Try to make filler surface as smooth as possible. Shape filler as it is applied.
5. Cheese-Grating Body Filler	5. Filler is ready to be cheese-grated when it is semi-hard (i.e., can be scratched with a fingernail). Hold cheese grater at a 30° angle. Pull it lightly across filler. Shape filler to approximate contour of the panel (slightly higher than original contour).
6. Rough-Sanding Filler	6. Use 36- to 40-grit sandpaper to rough-sand. Shape to original contour, leaving filler slightly higher than surrounding area.
7. Intermediate-Sanding Filler	7. Use 80- to 100-grit sandpaper to remove sand scratches left by rough-sanding. Smooth filler to original panel shape and contour.
8. Final-Sanding Filler	8. Use 180-grit sandpaper to remove sand scratches left by intermediate sanding.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover mixing ratios. The applied science teacher could provide information about the properties of body fillers (resins, polyesters, etc.) and chemical reactions.

Review:

Ask students review questions such as the following:

1. If you mix filler improperly, what could be the result?
2. What safety precautions should be followed when handling fillers and hardeners?
3. True or False: Filler should be applied in thick coats.
4. When can a cheese grater be used on body filler?
5. What grits of sandpaper are used to rough-sand filler? to do intermediate sanding? to finish-sand filler?

Application:

1. Provide students with a variety of different fillers and hardeners, and ask them to compare their mixing directions and summarize the differences.
2. Divide students into four groups. Have Group 1 properly mix filler. Have Group 2 overmix with hardener. Have Group 3 undermix with hardener. And have Group 4 fail to mix thoroughly. Have each group examine all four samples and summarize their observations.
3. As students practice applying body filler to damaged panels, using a cheese grater to rough-shape the filler, and sanding filler to proper shape, quiz them individually on the process (e.g., ask them to explain how they will determine when the filler is ready to be cheese-grated).

Evaluation:

√ The student will perform body filling procedures. His/her performance will be evaluated using a copy of the performance checklist for Competencies 2.3.6–2.3.8.

Competency 2.3.6: Mix body filler
Competency 2.3.7: Apply body filler; cheese-grate during curing
Competency 2.3.8: Rough sand cured body filler to contour; finish sand

Performance Checklist

In performing body filling procedures, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed filler on clean, nonporous mixing board	☐	☐	☐	☐	☐
4. Kneaded hardener prior to use	☐	☐	☐	☐	☐
5. Added appropriate amount of hardener for amount of mixer used	☐	☐	☐	☐	☐
6. Used appropriate spreader motion to mix product	☐	☐	☐	☐	☐
7. Mixed until product was a uniform color	☐	☐	☐	☐	☐
8. Applied body filler correctly, including—					
a. Used a clean spreader	☐	☐	☐	☐	☐
b. Used a firm pressure	☐	☐	☐	☐	☐
c. Applied thin layers	☐	☐	☐	☐	☐
d. Made filler surface as smooth as possible	☐	☐	☐	☐	☐
9. Ensured that filler was semi-hard before using cheese grater	☐	☐	☐	☐	☐
10. Held cheese grater at 30° angle	☐	☐	☐	☐	☐
11. Shaped filler slightly higher than original contour using cheese grater	☐	☐	☐	☐	☐
12. Smoothed filler to original panel shape and contour using three phasing of sanding. rough, intermediate, and final	☐	☐	☐	☐	☐
13. Used appropriate type of sandpaper (grit) for each phase	☐	☐	☐	☐	☐
14. Created a surface that was smooth and free of scratches	☐	☐	☐	☐	☐
15. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.1/2.5.1:	Identify weldable and non-weldable materials used in collision repair and refinish components
Competencies 1.4.3/2.5.3:	Determine the correct welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Determine the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.1/2.5.1 & 1.4.3/2.5.3

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when determining the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation. Show videos that show the materials, equipment, and steps used in welding processes.

Competency-Specific Information:

1. Present stories, news articles, etc., that illustrate the fact that deaths can result from incorrect welds made during vehicle repair.
2. Emphasize responsibility of every technician for being able to correctly identify weldable and non-weldable materials.
3. Show materials and equipment used in different welding processes.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Identifying Weldable and Non-Weldable Materials	2. To determine whether or not metals should be welded, you need to consider two things: • Characteristics • Location Characteristics of weldable materials: • Have fine grain structure, high luster • Accept the electrode metal Characteristics of non-weldable materials: • Have course grain structure, low luster • Do not accept the electrode metal To identify those characteristics, visually inspect a cross-section of the metal (not a polished surface). To identify whether the part is in a weldable location, use the appropriate chart in manufacturer's and/or I-CAR related tech manuals. • Locating appropriate chart • Interpreting charts

Presentation Outline	Steps to Cover/Key Points to Make
3. Selecting Correct Welder Type	3. Types of welders: • MIG (metal inert gas); also called GMAW (gas metal arc welding) • TIG (tungsten inert gas) • Oxyacetylene • ARC (electric arc) For collision repair— • MIG/GMAW is most often used. • TIG is rarely used. • Oxyacetylene and ARC are not used and not recommended. To select appropriate type of welder for a given task, check the manufacturer's specifications concerning the location of the weld. I-CAR and vehicle manufacturers recommend MIG welding as the preferred method for welding unibody vehicles.
4. Selecting Correct Electrode	4. Electrodes need to match manufacturer's specifications for the specific welder. Selected electrode needs to be appropriate for the following: • Position of weld • Type of metal (e.g., steel, aluminum) • Thickness of metal
5. Selecting Correct Wire Type and Diameter	5. Wires are typed by two factors: • Type of metal (e.g., steel, aluminum) • Tensile strength Tensile strength is measured in foot pounds. A number on the wire—assigned by the American Welding Society—can be used to look up its tensile strength.

Presentation Outline	Steps to Cover/Key Points to Make
	Wire diameters are identified to the nearest thousandths of an inch. Wire diameters in collision repair: • 0.023"—most commonly used • 0.030"—not used extensively • 0.035"—used mainly in frame repair Guidelines for selecting appropriate wire type and diameter for a given task: • Select wire type in accordance with welding equipment manufacturer's specification charts. • Use high-tensile wire for structural repair. • Low-tensile wire can be used for non-structural repair. • Select wire diameter based on the thickness of the metal. **Key Point:** Thicker metal requires thicker-diameter wire.
6. Selecting Correct Gas	6. Types of gas: • Argon • CO_2 • CO_2/Argon mix • Helium The appropriate gas to use is based primarily on the type of metal to be welded. For example: • Argon must be used for aluminum. • CO_2 or CO_2/Argon is used for steel. • CO_2/Argon is the preferable gas to use on high-strength steel because it maintains a smaller heat zone. • CO_2—a cheaper gas—is sometimes an acceptable alternative for use on high-strength steel, but the heat zone is larger. • Helium is used for steel. **Key Point:** Whenever you are selecting a gas for use in welding, environmental and health concerns should also be an issue.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could develop students' understanding of (1) porosity and how it affects welds and the welding process; (2) tensile strength and its measurement in foot pounds; and (3) gases used in welding, their characteristics, their effects on metal, and related environmental and health issues. The applied math teacher could help students measure in foot pounds and understand the differences in wire diameters (e.g., by measuring their diameter using a micrometer).

Review:

Ask students review questions such as the following:

1. What makes a material non-weldable?
2. What are some examples of the locations where weldable and non-weldable materials can be found?
3. What are the major determining factors in selecting the correct materials and equipment for a specific welding situation?

Application:

1. Provide students with a variety of metals (e.g., aluminum, cast aluminum, cast iron, mild steel, high-strength steel, high-strength/low-alloy steel), and have them work individually to determine weldable/non-weldable characteristics of those metals. **Note:** Some non-metals could be included to ensure that students can differentiate between metals and non-metals. Have students compare their findings.
2. Provide students with common parts—both weldable (portions of frame rails, rocker area parts, B-pillars, quarter panels) and non-weldable (portions of frame rails, suspension parts)—and ask them to determine whether each part should be welded. This can be done on an individual, small-group, or whole-class basis.
3. For each of the weldable parts in #2 above, have students list materials and equipment needed to perform a specific type of weld.

Evaluation:

√ The student will determine the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.1/2.5.1 & 1.4.3/2.5.3.

Competencies 1.4.1/2.5.1: Identify weldable and non-weldable materials used in collision repair and refinish components

Competencies 1.4.3/2.5.3: Determine the correct welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation

Performance Checklist

In determining the correct material, welder type, electrode, wire type, diameter, and gas to be used in a specific welding situation, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Accurately determined whether material was weldable or non-weldable by checking the following:					
a. Material's characteristics	☐	☐	☐	☐	☐
b. Appropriate chart (manufacturer, I-CAR) on weldable locations	☐	☐	☐	☐	☐
3. Selected correct materials and equipment for given situation and manufacturer's specifications, including—					
a. Type of welder	☐	☐	☐	☐	☐
b. Type of electrode	☐	☐	☐	☐	☐
c. Type of wire	☐	☐	☐	☐	☐
d. Diameter of wire	☐	☐	☐	☐	☐
e. Type of gas	☐	☐	☐	☐	☐
4. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Perform welds

Criteria: In accordance with the criteria in the checklists for Competencies 1.4.2/2.5.2 & 1.4.14/2.5.14

Introduction:

General Introductory Techniques: Share personal experiences you have had when performing various welds in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Show students pictures and locations of each of these different types of welds. If possible, also show the welds on an actual vehicle in the lab.

2. Show students both high-quality and low-quality welds, and have them compare and list the differences.

3. Show students different types of welding equipment.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Set up equipment for performing specific weld in accordance with accepted procedures (1.4.4/2.5.4–1.4.7/2.5.7). Operate welding equipment following accepted procedures for producing a quality weld (1.4.8/2.5.8) **Key Point:** On thicker metals, a slight weaving motion of the gun may be needed in a specific welding process to ensure proper penetration and bead buildup.
3. **Tack Welds:** Characteristics	3. Tack welds are foundational welds for performing other welding operations. For example, tack welds should be made every 2"–3" along the welding joint prior to performing a continuous or stitch weld. Using tack welds in this manner maintains alignment and prevents distortion during other welding operations. When the other weld is made, the tack weld should blend in with it. A quality tack weld— • is round in appearance; • has equal penetration to all pieces; • has no undercut; and • has minimal bead buildup.

Presentation Outline	Steps to Cover/Key Points to Make
4. Performing Tack Welds	4. Position gun equally between all pieces to be welded. Hold gun steady (there must be no movement of the gun). Pull the trigger to release welding wire. Release wire to form a circle of sufficient size to penetrate and join all pieces.
5. **Continuous Welds:** Characteristics	5. A quality continuous weld— • has an even pattern of ripples throughout the weld; • has a convex appearance; • has little or no undercut; • is free of splattered material; • is bright and free of *scales* (excess loose metal); • has equal penetration to all pieces; • has a bead that is in line with the weld joint; and • extends the full length of the joint. **Key Point:** A common error in continuous welding is failing to start or finish at the ends of the joint. Incomplete welds—welds that do not extend the full distance—have points that lead to weld failure.
6. Performing Continuous Welds	6. Position gun equally between all pieces to be welded. At the edge of the metal, pull the trigger to release wire. Move the gun in the direction of the joint at a steady rate of speed that permits proper bead height without undercut. **Key Point:** Speed also affects rippling. Using an unsteady speed results in unequal ripple size and poor weld quality. Continue the process over the full extent of the joint.

Presentation Outline	Steps to Cover/Key Points to Make
7. **Stitch Welds:** Characteristics	7. A quality stitch weld has all the characteristics of a continuous weld and should be indistinguishable from it if completed properly.
8. Performing Stitch Welds	8. A stitch weld is performed using a process nearly identical to that used for a continuous weld. The only ***difference*** is that in performing a stitch weld, the welding gun is frequently triggered on and off. The on/off cycling is determined by the thickness of the metals being welded and/or the speed of welding. On/off cycling can be manual or automatic, depending on the type of machine. **Key Point:** The gun should be moved only during the ON part of the cycle. The gun must be held steady during the OFF part of the cycle
9. **Lap Welds:** Characteristics	9. Lap welds connect overlapping pieces of metal. The weld joint runs along the edge of the upper piece of metal. A quality lap weld has many of the same characteristics as a continuous weld, except for the differences resulting from the overlap of the pieces. Thus, a quality lap weld— • has total penetration on the bottom piece; • is convex enough to absorb the edge of the upper piece of metal; and • has no undercut on the upper edge of the upper piece of metal.

Presentation Outline	Steps to Cover/Key Points to Make
10. Performing Lap Welds	10. Position the weld gun at a 45° angle to the welding surface and at a 45° angle to the edge of the upper piece of metal. Use a slight weaving motion as you move the gun along the joint to be welded, going from upper to lower pieces. Maintain a speed that produces a convex weld between the pieces, without causing an undercut.
11. **Plug Welds:** Characteristics	11. Plug welds connect overlapping pieces and are used to replace factory-produced spot welds. The plug welds should duplicate the size and number of factory welds to restore the vehicle to manufacturer's specifications. A quality plug weld— • is 5/16"–3/8" in size; • totally penetrates the lower pieces of metal, leaving a small bump on its back side; • totally fills the drilled hole of the upper piece; and • has a convex surface.
12. Performing Plug Welds	12. Drill 5/16"–3/8" hole in upper piece of metal. Position the gun at a 75°–90° angle to the hole. Trigger release of wire. Immediately rotate gun around hole until hole is filled and convex surface is formed.

Presentation Outline	Steps to Cover/Key Points to Make
13. **Spot Welds:** Characteristics	13. Spot welds are welded spots between two overlapping pieces of metal. They are only acceptable when done by electrical resistance processes performed with pressure-type (clamp) equipment. The spot welds should duplicate the size and number of factory welds. A quality spot weld— • is slightly indented on the top piece of metal, and • is slightly convex on the back piece.
14. Performing Resistance Spot Welds	14. Adjust welding machine timer to ensure total penetration. Place resistance contacts to metal. Pull trigger to release electric current. Wait for timer to shut off.
15. **Reinforced-Butt Welds:** Characteristics	15. A reinforced-butt weld involves three pieces of metal. One piece is placed below the other two pieces and the joint to be welded. A reinforced-butt weld is a combination of plug, tack, and continuous welding, respectively; and a quality reinforced-butt weld should have the desired characteristics of each. All pieces of metal must fit tightly together.
16. Performing Reinforced-Butt Welds	16. Drill 5/16" holes in upper pieces of metal, 2"–3" apart. Position the three pieces for welding. Perform plug welds. Perform tack welds. Perform continuous weld.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on the molecular structure of metals, the making of metals, characteristics of different types of metals, effects of heat on metal (e.g., distortion), and heat transfer in metals. The applied mathematics teacher could work with students on techniques for measuring temperatures during the welding process.

Review:

Ask students review questions such as the following:

1. What characteristics do quality lap, stitch, continuous, and reinforced butt welds have in common?
2. Why are plug and spot welds used on vehicles, and what is the proper method for using these types of welds?
3. What is the purpose of the weaving motion used with the welding gun?

Application:

1. As students practice performing different welds, quiz them individually on the process (e.g., ask them to explain the quality criteria for the particular weld they are performing).
2. Ask students to evaluate each of their practice welds using the quality criteria for that type of weld and select their three best welds to submit to the instructor.

Evaluation:

√ The student will perform welds. His/her performance will be evaluated using a copy of the performance checklists for Competencies 1.4.2/2.5.2 & 1.4.14/2.5.14. There is one checklist for each of the seven types of welds to be performed.

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing continuous welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun equally between all pieces to be welded	☐	☐	☐	☐	☐
4. Pulled trigger to release welding wire at edge of metal	☐	☐	☐	☐	☐
5. Moved gun in direction of joint	☐	☐	☐	☐	☐
6. Moved gun at steady rate of speed that permitted proper bead height without undercut	☐	☐	☐	☐	☐
7. Continued process over full extent of joint	☐	☐	☐	☐	☐
8. Produced a continuous weld that met the following quality criteria:					
a. Had an even pattern of ripples throughout weld	☐	☐	☐	☐	☐
b. Had a convex appearance	☐	☐	☐	☐	☐
c. Had little or no undercut	☐	☐	☐	☐	☐
d. Was free of splattered material	☐	☐	☐	☐	☐
e. Was bright and free of scales	☐	☐	☐	☐	☐
f. Had equal penetration to all pieces	☐	☐	☐	☐	☐
g. Had a bead that was in line with the weld joint	☐	☐	☐	☐	☐
h. Extended the full length of the joint	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 1.4.2/2.5.2: Weld [and cut] high-strength steel and other metals using manufacturer's procedures

Competencies 1.4.14/2.5.14: Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing stitch welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun equally between all pieces to be welded	☐	☐	☐	☐	☐
4. Pulled trigger to release welding wire at edge of metal	☐	☐	☐	☐	☐
5. Moved gun in direction of joint	☐	☐	☐	☐	☐
6. Triggered gun on and off frequently in accordance with thickness of metals being welded and/or speed of welding	☐	☐	☐	☐	☐
7. Moved gun only during ON part of cycle, with gun held steady during OFF part of cycle	☐	☐	☐	☐	☐
8. Continued process over full extent of joint	☐	☐	☐	☐	☐
9. Produced a stitch weld that met the following quality criteria:					
a. Had an even pattern of ripples throughout weld	☐	☐	☐	☐	☐
b. Had a convex appearance	☐	☐	☐	☐	☐
c. Had little or no undercut	☐	☐	☐	☐	☐
d. Was free of splattered material	☐	☐	☐	☐	☐
e. Was bright and free of scales	☐	☐	☐	☐	☐
f. Had equal penetration to all pieces	☐	☐	☐	☐	☐
g. Had a bead that was in line with the weld joint	☐	☐	☐	☐	☐
h. Extended the full length of the joint	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing tack welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun equally between all pieces to be welded	☐	☐	☐	☐	☐
4. Held gun steady, with no movement	☐	☐	☐	☐	☐
5. Pulled trigger to release welding wire	☐	☐	☐	☐	☐
6. Released wire to form circle of sufficient size to penetrate and join all pieces	☐	☐	☐	☐	☐
7. Produced a tack weld that met the following quality criteria:					
a. Was round in appearance	☐	☐	☐	☐	☐
b. Had equal penetration to all pieces	☐	☐	☐	☐	☐
c. Had no undercut	☐	☐	☐	☐	☐
d. Had minimal bead buildup	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

1.4.2/2.5.2 & 1.4.14/2.5.14

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing plug welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Drilled 5/16"–3/8" hole in upper piece of metal	☐	☐	☐	☐	☐
4. Positioned gun at 75°–90° angle to hole	☐	☐	☐	☐	☐
5. Pulled trigger to release welding wire	☐	☐	☐	☐	☐
6. Rotated gun around hole until hole was filled and convex surface was formed	☐	☐	☐	☐	☐
7. Produced a plug weld that met the following quality criteria:					
a. Was 5/16"–3/8" in size (duplicating factory size)	☐	☐	☐	☐	☐
b. Totally penetrated lower pieces of metal, leaving small bump on its back side	☐	☐	☐	☐	☐
c. Totally filled the drilled hole of the upper piece	☐	☐	☐	☐	☐
d. Had a convex surface	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing spot welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Adjusted welding machine timer to ensure total penetration	☐	☐	☐	☐	☐
4. Placed resistance contacts to metal	☐	☐	☐	☐	☐
5. Pulled trigger to release electric current	☐	☐	☐	☐	☐
6. Waited for timer to shut off	☐	☐	☐	☐	☐
7. Produced a spot weld that met the following quality criteria:					
a. Was slightly indented on top piece of metal	☐	☐	☐	☐	☐
b. Was slightly convex on back piece	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**____________

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing reinforced-butt welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Drilled 5/16" holes in upper pieces of metal, 2"–3" apart	☐	☐	☐	☐	☐
4. Positioned three pieces of metal correctly for welding	☐	☐	☐	☐	☐
5. Performed plug welds in accordance with accepted procedures for that type of weld	☐	☐	☐	☐	☐
6. Performed tack welds in accordance with accepted procedures for that type of weld	☐	☐	☐	☐	☐
7. Performed continuous weld in accordance with accepted procedures for that type of weld	☐	☐	☐	☐	☐
8. Produced a reinforced-butt weld that met the quality criteria for each type of weld (plug, tack, continuous)	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Competencies 1.4.2/2.5.2:	Weld [and cut] high-strength steel and other metals using manufacturer's procedures
Competencies 1.4.14/2.5.14:	Perform the following welds: continuous, stitch, tack, plug, spot, reinforced-butt, and lap joints

Performance Checklist

In performing lap welds, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Positioned gun at 45° angle to welding surface and 45° angle to edge of upper piece of metal	☐	☐	☐	☐	☐
4. Moved gun along joint using a slight weaving motion, going from upper to lower pieces	☐	☐	☐	☐	☐
5. Maintained a speed that produced a convex weld between pieces without causing undercut	☐	☐	☐	☐	☐
6. Produced a lap weld that met the following quality criteria:					
a. Had total penetration on bottom piece	☐	☐	☐	☐	☐
b. Was convex enough to absorb edge of upper piece	☐	☐	☐	☐	☐
c. Had no undercut on upper edge of upper piece	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.2/2.5.2: [Weld and] cut high-strength steel and other metals using manufacturer's procedures

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid (e.g., a specific metal product to build), manufacturer's information, and while following all applicable safety guidelines
Behavior:	Cut high-strength steel and other metals
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.2/2.5.2

Introduction:

General Introductory Techniques: Share personal experiences you have had when cutting high-strength steel and other metals in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain importance of use of high-strength steel in today's automobile industry and the potential dangers when it is repaired incorrectly.
2. Describe how previous information about high-strength steel is no longer accurate, and bring students up-to-date with the changes.
3. If possible, heat pieces of high-strength steel so students can observe how heat changes the characteristics of high-strength steel (cracks, stretches, weaknesses).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Tools for Cutting High-Strength Steel	2. Standard cutting tools: • Plasma cutter • Cut-off tool • Reciprocating saw • Spot weld cutter • Air chisel
3. Performing Cutting Operations: General Guidelines	3. Each tool should be used in accordance with manufacturer's specifications. In most cases, the tool should be positioned at a 90° angle to the metal surface. The preciseness required in cutting may vary depending on circumstances. If a precise layout diagram is provided, it must be followed. The process should maintain as small a heat zone as possible in order to avoid molecular damage and distortion to the surrounding high-strength steel.

Presentation Outline	Steps to Cover/Key Points to Make
4. Using Layout Diagrams	4. Read the diagram by interpreting— • scale; • angles; and • lines (bend, cut). Transpose the diagram to the metal according to scale using a measuring tool and a square, a triangle, and/or a compass. Etch lines into metal with a scratch-all. **Key Point:** When precise cutting is required, the cutting line should be the edge, not the center, of the cut. The cut should be on the outside of the cutting line.
5. Selecting Cutting Tools: General Guidelines	5. To select the appropriate cutting tool, you should consider the following: • Cutting procedure to be done (e.g., sectioning, spot weld cutting) • Location of the needed cut on the vehicle • Cleanliness of the metal (e.g., amount of rust, paint, or sealers) Since today's accepted cutting tools all provide a low heat zone when used properly, heat-zone size is no longer a factor for selection.
6. Using a Plasma Cutter	6. Selection factors: • Used for sectioning or spot weld cutting. • If the plasma cutter is to be used for spot weld cutting, you must have access to both sides of the metal. • Plasma cutter size is selected based on the thickness of metal to be cut. • Due to hot, molten sparks produced by the cutter, areas around the cutting location should not be combustible. Glass and chrome areas should be well protected. • Metal to be cut should be clean (free of rust, paint, sealants).

Presentation Outline	Steps to Cover/Key Points to Make
	Preparation: • Make sure the plasma cutter has the voltage needed to cut through the thickness of the metal. • Clean metal so that it is free of rust, paint, and sealant, using mechanical (grinding) and/or chemical processes (2.1.2/2.1.4/2.1.6/2.1.7/2.18). • Attach ground clamps (1.4.4/2.5.4). Cutting procedure: • Position plasma gun. • Pull trigger to begin cutting. • Make the cut to prescribed preciseness at a steady rate of speed.
7. Using a Cut-off Tool	7. Selection factors: • Used only for sectioning. • Cannot be used in confined areas (e.g., corners) where binding may occur. • Can be used to cut contaminated metals (painted, rusted, sealant-covered). Preparation: • Protect surrounding areas from hot sparks. • Adjust air pressure to manufacturer's specifications. • Select blade based on speed of grinder and type of metal to be cut. Cutting procedure: • Position the cutter. • Pull trigger to begin cutting. • Make the cut, holding the gun only tight enough to maintain control. Holding it too tight may cause binding.

Presentation Outline	Steps to Cover/Key Points to Make
8. Using a Reciprocating Saw	8. Selection factors: • Used only for sectioning. • Cannot be used in confined areas (e.g., corners) where binding may occur. • Can be used to cut contaminated metals. Preparation: • Select blade length and type based on type of metal and distance to be cut. • Attach selected blade. Cutting procedure: • Position the cutter. • Pull trigger to begin cutting. • Make the cut, holding the cutter tight against the surface.
9. Using a Spot Weld Cutter	9. Selection factors: • Used only for removal of factory spot welds. **Note:** This is the preferred tool for removing spot welds. • Can be used on a factory spot weld in any location. • Can be used to cut contaminated metals. Preparation: • Select blade diameter size that is large enough to remove entire spot weld. • Select drill with an RPM that matches the blade requirements. Cutting procedure: • Center drill with attached blade over spot weld. • Pull trigger to begin cutting. • Apply even pressure until the *stop* is reached. • Break spot weld cut with chisel to remove metal.

Presentation Outline	Steps to Cover/Key Points to Make
10. Using an Air Chisel	10. Selection factors: • Used for sectioning and spot weld cutting. • If used for sectioning, some minor warpage of metal (e.g., on non-structural parts) must be acceptable. • Can be used in any accessible location. • Can be used to cut contaminated metals. Preparation: • Adjust air pressure according to manufacturer's specifications. • Select appropriate well-sharpened chisel blade (e.g., a ripping blade for making rough cuts, a spot weld blade to break spot welds). **Key Point:** Chisel blades need to be very sharp for ease of cutting. Cutting procedure: • Position chisel with attached blade firmly against metal to be cut. • Pull trigger to begin cutting. • Make the cut using an even, steady pressure.
11. Welding High-Strength Steel	11. Follow standard procedures (1.4.2/2.5.2 & 1.4.14/2.5.14).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on the molecular structure of metals, the making of metals, characteristics of different types of metals, the history of steel, effects of heat on metal (e.g., distortion), and heat transfer in metals. The applied mathematics teacher could work with students on techniques for measuring temperatures during the welding process and for obtaining measurements from blueprints and the mathematics of using layout tools (e.g., squares, triangles, compasses).

Review:

Ask students review questions such as the following:

1. If high-strength steel is improperly welded, what could be the effects?
2. How does heat affect the molecular structure of steel?
3. If there is too large a heat zone during the welding of high-strength steel, what could be the possible results?

Application:

1. Have students cut metal using an acceptable procedure while the instructor uses a nonacceptable procedure (e.g., oxyacetylene cutting). Then ask the students to identify the size of the heat zones (e.g., using heat crayons) and determine whether they meet manufacturer's requirements.
2. Divide students into small groups, and ask them to examine a vehicle that will be scrapped from the program and to identify and label the various types of metal. Once you have verified their findings, have them practice cutting the different types of metal.

Evaluation:

√ The student will cut high-strength steel and other metals. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.2/ 2.5.2.

Competencies 1.4.2/2.5.2: [Weld and] cut high-strength steel and other metals using manufacturer's procedures

Performance Checklist

In cutting high-strength steel and other metals, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected tool(s) appropriate for specific cutting tasks	☐	☐	☐	☐	☐
3. Selected tool(s) appropriate for specific welding tasks	☐	☐	☐	☐	☐
4. Performed cuts in accordance with generally accepted procedures for each of the following tools:					
a. Plasma cutter	☐	☐	☐	☐	☐
b. Die grinder	☐	☐	☐	☐	☐
c. Metal saw cutter	☐	☐	☐	☐	☐
d. Spot weld cutter	☐	☐	☐	☐	☐
e. Air chisel	☐	☐	☐	☐	☐
5. Followed layout diagram exactly in making cuts	☐	☐	☐	☐	☐
6. Performed welds in accordance with equipment manufacturer's specifications	☐	☐	☐	☐	☐
7. Maintained proper heat zones during cutting and welding	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.4/2.5.4:	Set up welding equipment
Competencies 1.4.5/2.5.5:	Adjust the welder to "tune" for proper electrode stickout, voltage, polarity, flow rate, and wire-feed speed required for the material being welded
Competencies 1.4.6/2.5.6:	Store, handle, and install high-pressure gas cylinders
Competencies 1.4.7/2.5.7:	Determine work clamp (ground) location and attach
Competencies 1.4.8/2.5.8:	Use the proper angle of the gun to the joint and the direction of the gun travel for the type of weld being made in the flat, horizontal, vertical, and overhead positions

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Set up, adjust, operate, and maintain welding equipment
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.4./2.5.4–1.4.8/2.5.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when setting up, adjusting, operating, and maintaining welding equipment in the collision repair facility. Show videos related to welding equipment setup.

Competency-Specific Information:

1. Emphasize relationship of proper equipment setup to safety, work efficiency, and quality welds. Give examples of situations in which improper setup has caused problems and cost time and money.

2. Explain how angle and direction of welding gun can affect weld quality.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Setting Up Welding Equipment for a Specific Operation: General Guidelines	2. Select correct materials and equipment (1.4.1/2.5.1 & 1.4.3/2.5.3). Ensure sufficient reach of welding equipment to welding work area. Check that ground cables are in place on welding equipment. Attach ground clamps to welding object. **Key Point:** Ground clamps must be attached to clean, bare metal in close proximity to welding area.
3. Setting Up MIG Equipment	3. In addition to general setup procedures, you need to do the following: ◆ Install the welding wire, electrode, and gas nozzle, respectively, in accordance with manufacturer's specifications. ◆ Install the high-pressure gas cylinder. **Key Point:** The cylinder should always be chained in place during storage and installation. ◆ Install the flow meter. **Key Points:** Before installation of flow meter, always purge the cylinder. After installation, always check the flow meter for leaks.

Presentation Outline	Steps to Cover/Key Points to Make
4. Adjusting Welding Equipment: General Guidelines	4. Follow manufacturer's specifications for voltage, wire-feed speed, related gas pressure, tip size, wire size, and flow rate, as applicable. Each of these specifications will vary by manufacturer and by type of welding equipment.
5. Adjusting MIG Equipment	5. In addition to general adjustment procedures, you need to do the following: • Use manufacturer's specifications to determine proper adjustment of voltage, polarity, wire-feed speed, and flow rate for the specific material to be welded. **Note:** When properly adjusted, the welding sound is much like bacon frying. • Adjust stickout based on anticipated angle and direction of welder gun use (1/4"–1/2"). **Key Point:** Stickout should never be more than 1/2" or less than 1/4".
6. Operating Welding Equipment	6. Keep the welder at a 45°–60° angle in line with the direction of the weld. **Key Points:** • If proper equipment and materials have been selected, maintaining a 45°–60° angle ensures proper laydown of welding material. • If you have to deviate from the 45°–60° angle, pay close attention to the welding puddle to ensure complete penetration and weld laydown. Move the welding gun (drag, push) so that you maintain visibility of the welding puddle, regardless of weld position.

Presentation Outline	Steps to Cover/Key Points to Make
	Key Points: ◆ While welding in an overhead position, always pull the weld puddle toward self in order to maintain visibility of puddle. ◆ *Blind welding*—welding without being able to see the puddle—occurs when this rule is violated. ◆ Overhead welding requires particular attention to safety and use of safety equipment.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on how to cost-out a welding operation and how rheostats calculate rate of delivery. The applied science teacher could discuss the use of electricity in welding; electrocution hazards; voltage, resistance, polarity, and flow rate; and how rheostat controls motor speed.

Review:

Ask students review questions such as the following:

1. What general concerns should be addressed in setting up welding equipment?
2. What sequence should be followed in setting up a MIG welder?
3. Where would you position a ground clamp, and why?
4. What is blind welding, and why is it a problem?

Application:

1. Give students written case studies describing various welding situations, and ask them to select the correct equipment angle and direction for each situation and to justify their answers.

2. Provide students with a variety of welds—some done with proper equipment angle and direction, and some done with improper angle and direction—and ask them to determine the effects of angle and direction on the quality of each weld.

3. Divide students into teams and assign each to design a poster, bulletin board, or video about one of the following:
   - Proper and improper angles and directions for welding operations and impact on weld quality
   - Welding equipment setup and procedures, including safety concerns
   - Storage, handling, and installation of high-pressure gas cylinders
   - Proper and improper grounding procedures
   - Procedure for tuning a MIG welder

4. Ask students to set up equipment using the team-prepared directions and provide feedback on the quality of the directions (ease of use, completeness, accuracy, etc.).

Evaluation:

√ The student will set up, adjust, operate, and maintain welding equipment. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.4./2.5.4–1.4.8/2.5.8.

Competencies 1.4.4/2.5.4:	Set up welding equipment
Competencies 1.4.5/2.5.5:	Adjust the welder to "tune" for proper electrode stickout, voltage, polarity, flow rate, and wire-feed speed required for the material being welded
Competencies 1.4.6/2.5.6:	Store, handle, and install high-pressure gas cylinders
Competencies 1.4.7/2.5.7:	Determine work clamp (ground) location and attach
Competencies 1.4.8/2.5.8:	Use the proper angle of the gun to the joint and the direction of the gun travel for the type of weld being made in the flat, horizontal, vertical, and overhead positions

Performance Checklist

In setting up, adjusting, operating, and maintaining welding equipment, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected proper materials and equipment for the specific welding operation	☐	☐	☐	☐	☐
3. Ensured setup had sufficient electrical supply	☐	☐	☐	☐	☐
4. Stored, handled, and installed gas cylinders properly	☐	☐	☐	☐	☐
5. Adjusted MIG welder to manufacturer's specifications, including—					
a. Stickout	☐	☐	☐	☐	☐
b. Voltage	☐	☐	☐	☐	☐
c. Polarity	☐	☐	☐	☐	☐
d. Flow rate	☐	☐	☐	☐	☐
e. Wire-feed speed	☐	☐	☐	☐	☐
6. Operated welding equipment using proper angle and direction for each welding position, including—					
a. Flat	☐	☐	☐	☐	☐
b. Horizontal	☐	☐	☐	☐	☐
c. Vertical	☐	☐	☐	☐	☐
d. Overhead	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.9/2.5.9:	Protect adjacent panels, glass, vehicle interior, etc., from welding and cutting operations
Competencies 1.4.10/2.5.10:	Protect computers and other electronic control modules during welding procedures according to manufacturer's specifications
Competencies 1.4.11/2.5.11:	Clean and prepare the metal for welding; fit, align, and clamp as required

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Prepare a vehicle for welding and cutting operations

Criteria: In accordance with the criteria in the checklist for Competencies 1.4.9/2.5.9–1.4.11/2.5.11

Introduction:

***General Introductory Techniques**:* Share personal experiences you have had when preparing vehicles for welding and cutting operations in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Give examples of damage that occurred during welding operations as a result of poor protection and the consequences of that damage in terms of labor and costs. Emphasize that simple repairs can turn into major repairs as a result of carelessness (e.g., welding sparks embedded in glass or chrome, damaged computers and other electronic parts).

2. Give examples of improper fit and alignment and the impact in terms of additional work, downtime, and cost of the job.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safety Practices	2. For welding, fire extinguishment procedures and personal safety equipment should be a special focus.
3. Protecting Vehicle Parts During Cutting and Welding to Prevent Damage	3. Determine all vehicle parts (interior and exterior) that could be damaged during welding and cutting procedures. Determine whether part needs to be removed or protected in place. Determine type of potential damage to part. **Key Point:** The most common causes of damage are sparks, heat, and dust. To protect against spark damage: • Use nonflammable coverings (metal pieces, fire blankets). • Can use protective tapes on exterior glass and metal and plastic parts. To protect against potential dust damage: • Use plastic sheets or paper to cover the parts. **Key Point:** This applies to dust damage only—and only in areas where no potential damage from sparks or heat is possible. • Special attention should be given to dash assembly, openings, and cloth interior parts.

Presentation Outline	Steps to Cover/Key Points to Make
	To protect against heat damage: • Remove interior parts or exterior trim (preferred method). • Protect with a heat absorbent material (e.g., heat dam) if parts are not easily removed. **Key Point:** Do not use asbestos material for heat protection.
4. Protecting Computers and Other Electronics from Electrical Damage	4. Use manufacturer's service manuals to determine special precautions and locations of electronic controls. Follow manufacturer's specifications for protection. **Key Point:** For some controls, removal is required. For others, disconnection of ground and battery power wire is all that is necessary.
5. Pre-Measuring Parts and Welding Areas	5. Proper measurement prior to welding is critical to ensure fit and alignment of parts after the welding operation is completed and to prevent having to redo a welding operation. Pre-measure part(s) and surrounding area. Important measurements include length, width, and X. For proper fit, the gap between the two parts to be welded must be no wider than the thickness of the metal. For alignment, check manufacturer's specifications to identify proper sizes of opening gaps. If fit is improper, a cutting operation may be needed in order to get a proper fit (1.4.2/2.5.2). **Key Point:** When a cutting operation is needed, the cutting width must be accounted for during pre-measurement. Different cutting tools have different cutting widths, which affects the final measurements.

Presentation Outline	Steps to Cover/Key Points to Make
6. Cleaning Welding Areas	6. Clean all welding areas as follows: • Steel needs to be cleaned to bare surface. • For galvanized, remove paint but leave galvanized coating. **Key Point:** Although some of the galvanized layer must be removed, leave as much as possible. During welding, it remelts and heals the welded area with a galvanized coating.
7. Applying Primer	7. Apply a weld-through primer on areas that will not be accessible after completion of the welding operation.
8. Clamping Parts	8. Parts must be clamped for sufficient support and maintenance of proper fit and alignment measurement.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover measurement in relationship to fit and alignment work, helping students learn to measure in millimeters. Geometric concepts could be taught in relationship to learning to make X-measurements. The applied science teacher could provide lessons about galvanization processes and how computer and electronic controls can be damaged during cutting and welding operations.

Review:

Ask students review questions such as the following:

1. What is the importance of making proper measurements prior to welding?
2. What are the most common causes of damage to vehicle parts during welding and cutting operations?
3. How does computer and electronic control damage occur during welding and cutting operations?
4. What is the difference between the welding preparation procedures used for steel and galvanized steel?

Application:

1. Give students written case studies describing different welding and cutting situations, and ask them to describe how to protect each vehicle (parts, computers, electronic controls) during the welding or cutting operation.
2. Provide students with pieces of metal, and ask them to prepare them for welding as if they were vehicle parts. Then have students exchange parts and review each other's work for cleanliness and fit.

Evaluation:

√ The student will prepare a vehicle for welding and cutting operations. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.9/2.5.9–1.4.11/2.5.11.

Competencies 1.4.9/2.5.9:	Protect adjacent panels, glass, vehicle interior, etc., from welding and cutting operations
Competencies 1.4.10/2.5.10:	Protect computers and other electronic control modules during welding procedures according to manufacturer's specifications
Competencies 1.4.11/2.5.11:	Clean and prepare the metal for welding; fit, align, and clamp as required

Performance Checklist

In preparing a vehicle for welding and cutting operations, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Accurately determined possibility of damage to parts by sparks, dust, heat	☐	☐	☐	☐	☐
4. Accurately determined possibility of damage to computer and electronics controls	☐	☐	☐	☐	☐
5. Selected proper protection procedure, including—					
a. Removal of part(s)	☐	☐	☐	☐	☐
b. Coverage of part(s)	☐	☐	☐	☐	☐
c. Disconnection from power source and ground	☐	☐	☐	☐	☐
6. Properly applied selected protection materials	☐	☐	☐	☐	☐
7. Correctly measured parts and surrounding area	☐	☐	☐	☐	☐
8. Cleaned area and removed coatings using procedure appropriate for type of metal	☐	☐	☐	☐	☐
9. Properly clamped parts for support, fit, and alignment	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____Date______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.12/2.5.12:	Determine the joint type (reinforced-butt, lap, etc.) for weld being made according to manufacturer's/industry specifications
Competencies 1.4.13/2.5.13:	Determine the type of weld (continuous, reinforced-butt, plug, etc.) for each specific welding operation according to manufacturer's/industry specifications

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Determine joint type and type of weld for each specific welding operation

Criteria: In accordance with the criteria in the checklist for Competencies 1.4.12/2.5.12 & 1.4.13/2.5.13

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when determining joint type and type of weld for each specific welding operation. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Discuss the effects of vibration and stress on auto body structure over time, and show examples of welds that have not held up.

2. Discuss the effect of improper weld joints on overall structural integrity, and explain what can happen in an accident.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Determining Joint Type	2. Type of joint to be made is determined by two factors: • Location of joint on vehicle • Whether the repair area is structural or non-structural For structural repairs in most areas, the original joint must be closely duplicated. However, a reinforced-butt joint is acceptable in non-weight-bearing areas. For non-structural repairs, the new joint may or may not be the same as the original joint. In many instances, a new joint is created through sectioning. In high-vibration areas, a reinforced joint (lap, reinforced-butt) must be made.

Presentation Outline	Steps to Cover/Key Points to Make
3. Determining Weld Type	3. Type of weld to be made is determined by type of joint to be made. For structural repairs, use joints that duplicate the original welds, resistance-spot welds, and plug welds. **Note:** It is impossible to duplicate a factory weld in most collision repair facilities. The above welds come closest to matching the original welds. Any structural repair that is done by sectioning requires a reinforced-butt weld. For non-structural repairs, a lap weld can be used in low-vibration areas. In high-vibration areas, a reinforced-butt weld is required.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss and/or demonstrate the effects of vibration on molecular structure.

Review:

Ask students review questions such as the following:

1. What are the major determining factors in deciding what type of joint to use?
2. How should you determine the type of weld to be made?

Application:

1. Provide students with pictures of damaged auto body parts, and ask them to determine whether weld joints are needed in each case. Where weld joints are needed, have students identify the proper joint to be made and welds needed to make the joint. Ask them to justify their decisions.
2. Provide students with examples of weld joint types, and have them identify each and explain (a) where the joint can be used, and (b) what welds were used to create the joint.

Evaluation:

√ The student will determine joint type and type of weld for each specific welding operation. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.12/2.5.12 & 1.4.13/2.5.13.

Competencies 1.4.12/2.5.12:	Determine the joint type (reinforced-butt, lap, etc.) for weld being made according to manufacturer's/industry specifications
Competencies 1.4.13/2.5.13:	Determine the type of weld (continuous, reinforced-butt, plug, etc.) for each specific welding operation according to manufacturer's/industry specifications

Performance Checklist

In determining joint type and type of weld for each specific welding operation, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Correctly identified type of repair area: structural or non-structural	☐	☐	☐	☐	☐
3. Determined whether weld would be made in a stress or vibration area	☐	☐	☐	☐	☐
4. Identified type of joint appropriate for specific location	☐	☐	☐	☐	☐
5. Identified type of weld appropriate for joint to be made	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________ **Date**______________

Competencies 1.4.15/2.5.15: Perform destructive tests on each weld type

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform destructive tests on each weld type
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.15/ 2.5.15

Introduction:

General Introductory Techniques: Share personal experiences you have had when performing destructive tests on welds in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Explain the importance of performing destructive tests on practice welds (e.g., liability issues, ability to make adjustments before actual welding process).

2. Welds are usually tested using expensive, sophisticated equipment, but the technician can perform a destructive test with simple hand and power tools .

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Types of Welds To Be Tested	2. Butt weld Reinforced-butt weld Lap weld Plug weld Resistance spot weld
3. Performing Destructive Tests	3. Create a practice panel weld of same type and thickness as weld to be performed. **Note:** Duplicate original as closely as possible. Butt weld/lap weld destructive test: • Place panel in a vise, with the jaws just below the weld. • Bend the panel back and forth until it breaks. • Panel should break on either side of the weld, but not at the weld itself. Reinforced-butt weld destructive test: • Place panel in a vise, with the jaws just below reinforcement area. • Bend the panel back and forth until it breaks. • Panel should break on either side of the main weld, with reinforcement remaining attached to one or both sides of main weld area.

Presentation Outline	Steps to Cover/Key Points to Make
	Plug weld destructive test: • Place panel in a vise, with the jaws just below the plug welds. • Break the plug weld using a hammer or chisel. • This should create a hole that has a slightly torn look around the edges. Resistance spot weld destructive test: • Place two strips of metal at right angles to each other, and weld them together using a resistance spot welder. • Apply force, moving both pieces toward one another until the weld breaks. • Weld should have a very distinct round hole in the surface of one panel.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover metallurgy, molecular structure of metal (prior to and after welding), and destructive testing used by engineers in high-tech labs. The applied mathematics teacher could explain pounds per square inch (psi), force, and measurement of force.

Review:

Ask students review questions such as the following:

1. Why is it important to create test pieces and perform destructive tests?
2. What are the characteristics of a quality weld when performing destructive tests?

Application:

1. Have students create test pieces and perform destructive tests on the various types of welds.
2. Allow students to remove sections of welded areas from vehicles to be scrapped from program and then perform destructive tests on the factory welds.
3. Have students compare the results from their destructive tests on factory and non-factory welds.

Evaluation:

- √ The student will perform destructive tests on each weld type His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.15/ 2.5.15.

Competencies 1.4.15/2.5.15: Perform destructive tests on each weld type

Performance Checklist

In performing destructive tests on each weld type, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Performed each weld on practice panel	☐	☐	☐	☐	☐
4. Mounted panel correctly in vise	☐	☐	☐	☐	☐
5. Performed correct destructive test in accordance with standard testing procedure	☐	☐	☐	☐	☐
6. Accurately identified all weld failures	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____Date______________

Units 1/2: Structural and Non-Structural Analysis and Damage Repair

Subunits 1.4/2.5: Metal Welding and Cutting

Competencies 1.4.16/2.5.16:	Identify the causes of spits and sputters, burn through, lack of penetration, porosity, incomplete fusion, excessive spatter, distortion, and waviness of bead; make necessary adjustments
Competencies 1.4.17/2.5.17:	Identify cause of contact tip burn-back and failure of wire to feed; make necessary adjustments

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Identify causes of welding problems, and make necessary adjustments
Criteria:	In accordance with the criteria in the checklist for Competencies 1.4.16/2.5.16 & 1.4.17/2.5.17

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when identifying causes of welding problems and making necessary adjustments. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Many problems that occur during MIG welding are due to operator error (e.g., improper setup or operation of the welding machine).

2. These problems must be diagnosed and corrected because they will produce poor weld quality—which, in turn, can lead to weld failure.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Spits and Sputters	2. Spits and sputters create an inconsistent welding sound and leave rough deposits on the base material. Possible causes: • Wire speed and/or voltage setting need adjustment. **Key Point:** If the voltage/wire-speed ratio is correct, you will hear an even, high-pitched, buzzing sound. This sound has often been compared to that of bacon frying in a pan. • Gas cylinder valve is not fully open, or flow meter is improperly adjusted. Check manufacturer's specifications, and make necessary adjustments.
3. Burn-Through	3. With burn-through, holes appear in weld joint or base material. Possible causes: • Voltage is too high. • Gun travel speed is too slow. • Gun to base distance is too close. • There is an excessive gap between welding surfaces. Check one item at a time, and adjust as necessary.

Presentation Outline	Steps to Cover/Key Points to Make
4. Lack of Penetration	4. Lack of penetration is caused by insufficient deposit of filler material, which does not penetrate weld joint completely. Possible causes: • Voltage is too low. • Gun travel speed is too fast. • Wire speed needs adjustment. **Note:** Wire speed needs to be in correct ratio with voltage (see Step 2). Check one item at a time, and adjust as necessary.
5. Porosity	5. Porosity refers to holes or pits in the weld bead caused by trapped gas. Possible causes: • Flow meter setting is incorrect. • There is rust or other contaminants in the weld area. • Electrode wire is the wrong size. • Weld joint surface is not clean. Check one item at a time, and adjust or clean as necessary.
6. Incomplete Fusion	6. In incomplete fusion, the weld joint is not fused evenly on both sides of base material. Possible causes: • There is dirt, rust, or other contaminants in the weld surface area. • Voltage setting is incorrect. • Wire speed is incorrect. Check one item at a time, and adjust or clean as necessary.

Presentation Outline	Steps to Cover/Key Points to Make
7. Excessive Spatter	7. Excessive spatter refers to speckles or bumps of molten metal on sides of weld joint. Possible causes: • Gas is off, or valve is not fully open. • Flow meter setting is incorrect. • Voltage is too high. • Arc length is excessive. • Gun angle is incorrect. Gas cylinder valve must be fully open. Check remaining items one at a time.
8. Distortion in Weld Joint	8. Distortion in the weld joint means that the joint is uneven or the base material is warped. Possible causes: • There is an excessive gap between welding surfaces. • Voltage setting is too high. • Improper clamping or fastening methods were used. • There were not enough tack welds to hold metal in position prior to welding. **Key Point:** It is imperative that the base material be clamped, fastened, or tack-welded together to prevent the weld surface area from moving or separating. Check one item at a time, and adjust as necessary.

Presentation Outline	Steps to Cover/Key Points to Make
9. Waviness of Bead	9. A bead is "wavy" if it is not uniform in width. Possible causes: • Gun is not adequately controlled. **Key Point:** Gun control and movement will directly affect weld quality. • View of the weld puddle is obscured. **Key Point:** A clear view of the weld puddle is necessary to prevent *blind welding*, a condition in which the operator cannot see the weld surface area. Check one item at a time, and adjust as necessary.
10. Tip Burn-Back	10. Tip burn-back occurs when the electrode wire melts or sticks to gun tip. Possible causes: • Voltage setting is too high. • Wire speed is too slow. • Tip is dirty or needs to be replaced due to wear. • Tip-to-nozzle alignment is out of adjustment. • Tip or wire size is incorrect. Check one item at a time, and adjust, clean, or repair as necessary. **Key Point:** Make sure tip and wire size match (e.g., .023 tip and .023 wire).

Presentation Outline	Steps to Cover/Key Points to Make
11. Wire-Feed Failure	11. Wire-feed failure occurs when the electrode wire is not fed through welding gun cable properly. Possible causes: • Contact tip is burned back (see Step 10). • Gun cable or lines are defective or kinked. • There is dirt on guide rollers. • Guide roller is defective or worn out. • Tension on guide rollers is incorrect. • Tip and wire size don't match (see Step 10). • Wire-feed motor or switch is defective. • Electrode wire is dirty or contaminated (e.g., with rust, grease, oil). Check one item at a time, and adjust or clean as necessary. **Key Point:** Proper care, handling, and preventive maintenance will extend the life of welder parts. However, parts will eventually wear and need replacement. Deal with only those parts that can be repaired/replaced in the lab or shop area. Leave all other repairs to qualified repair personnel.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover metallurgy, inert and active welding gases, and electrical principles (e.g., polarity; AC/DC electrical currents; and amperage, voltage, flow, and resistance in electrical currents/circuitry). The applied mathematics teacher could work with students in measuring wire size, tip size, voltage, and amperage.

Review:

Ask students review questions such as the following:

1. What is the main cause of poor weld quality?
2. How do voltage and wire speed affect MIG welding?
3. Why should the gas valve be fully open?
4. Why is it necessary to remove contaminants (rust, dirt, grease) from the weld area?

Application:

1. Provide students with actual examples of weld problems created on a practice panel, and ask them to explain the possible cause of each problem.
2. For each problem shown in Activity 1, ask students to explain what effect the problem would have on the repair.

Evaluation:

√ The student will identify causes of welding problems and make necessary adjustments. His/her performance will be evaluated using a copy of the performance checklist for Competencies 1.4.16/2.5.16 & 1.4.17/2.5.17.

Competencies 1.4.16/2.5.16: Identify the causes of spits and sputters, burn through, lack of penetration, porosity, incomplete fusion, excessive spatter, distortion, and waviness of bead; make necessary adjustments

Competencies 1.4.17/2.5.17: Identify cause of contact tip burn-back and failure of wire to feed; make necessary adjustments

Performance Checklist

In identifying causes of welding problems and making necessary adjustments, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly identified the exact nature of the problem (spits and sputters, burn-through, etc.)	☐	☐	☐	☐	☐
4. Correctly identified the cause(s) of the problem	☐	☐	☐	☐	☐
5. Corrected each condition in accordance with established procedures	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.29: Measure vehicle ride height; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Measure vehicle ride height, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.29

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when measuring vehicle ride height and determining needed repairs. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Pass out handouts showing a vehicle, with arrows pointing from Point A (a level surface) to Point B (designated location on car).
2. Ask students if they know the term used for the distance between the two points.

References:

Service manuals; technical service bulletins (TSBs); wheel alignment specifications manual. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Purpose of Ride Height	2. Purpose = correct wheel alignment *Ride height* is the distance from the ground to a point on vehicle designated by manufacturer as height of vehicle for proper alignment. **Key Points:** • Ride height determines front and rear end alignment. • Ride height affects caster and camber and toe-in/toe-out of front wheels.
3. Measuring Ride Height	3. **Key Point:** When measuring ride height on a vehicle, be sure it is parked on a level surface. Use wheel alignment specifications manual to determine Point A and Point B for measurement purposes. Using a tape measure, measure ride height (Point A to Point B).

Presentation Outline	Steps to Cover/Key Points to Make
4. Determining Needed Repairs	4. If actual ride height differs from ride height specified by manufacturer, you need to determine the cause/problem. **Problem:** Tire air pressure low or tire defective **Solution:** Inflate tire to correct pressure, or replace tire. **Problem:** Bent suspension components **Solution:** Replace components as necessary. **Problem:** Bent frame or unibody **Solution:** Using frame rack, straighten frame or unibody to manufacturer's specifications. **Problem:** Weak or broken springs **Solution:** Remove and replace springs. **Key Point:** Any suspension part that is bent ***must*** be replaced.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could review both English and metric units of measure and could help students with vehicle steering and suspension geometry and load ratings on tires and springs. The applied science teacher could cover air pressure (psi) and how it changes in relation to temperature; how springs are made and their tensile strength.

Review:

Ask students review questions such as the following:

1. Define *ride height*.
2. Explain the purpose of ride height and its effects.
3. What could cause the measurement of ride height to be incorrect?

Application:

1. Give students alignment specification manuals, and have them measure and determine ride height on vehicles in the lab.
2. Create ride height problems on vehicles in the lab (e.g., lower air pressure in tires, remove or bend suspension components), and have students diagnose the problems.

Evaluation:

√ The student will measure vehicle ride height and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.29.

Competency 3.1.29: Measure vehicle ride height; determine needed repairs

Performance Checklist

In measuring vehicle ride height and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Used appropriate manuals to secure needed information	☐	☐	☐	☐	☐
3. Identified correct make and model of vehicle	☐	☐	☐	☐	☐
4. Measured from Point A to Point B with English and/or metric tape measure according to standard procedure	☐	☐	☐	☐	☐
5. Obtained accurate measurement	☐	☐	☐	☐	☐
6. If ride height varied from manufacturer's specifications, correctly identified cause of problem(s)	☐	☐	☐	☐	☐
7. Determined repairs needed to correct identified problem(s)	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.32: Inspect and replace steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels.

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect and replace steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.32

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting and replacing steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Set up an exhibit of an actual U-joint, flexible coupling, collapsible columns, and steering wheel. (Could enhance this activity by having two samples for each part: one new and one worn.)

2. Ask students whether anyone can identify each part and its purpose.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Steering Column Parts	2. Four main parts of steering columns: • Steering shaft U-joint(s) • Flexible coupling(s) • Collapsible column • Steering wheel
3. Inspecting Steering Shaft U-joint(s)	3. Visually inspect, looking for wear and/or too much movement in U-joints. Move steering wheel (left and right) to identify wear (e.g., excessive play in U-joint). Check amount of grease around joint: too little or too much (leakage).
4. Inspecting Flexible Coupling(s)	4. Look for worn or torn places in the rubber.
5. Inspecting Collapsible Column	5. Check for damage to shaft. Determine type of collapsible column: • Pinned shaft (most common)—pins will be broken if collapsed • Net shaft—net materials will be folded over if collapsed

Presentation Outline	Steps to Cover/Key Points to Make
6. Inspecting Steering Wheels	6. **Key Point:** Usually, the only time you need to inspect the steering wheel is following a frontal collision. Visually inspect the wheel to determine whether it is warped (bent) when turned (right to left or left to right).
7. Lifting Car	7. Vehicle must be placed on lift or jack stands, and front wheels must be removed.
8. Replacing Damaged Parts	8. **Key Point:** The #1 reason for replacing these parts is the liability issue due to safety factors. Refer to the textbook, handout, or service manual for specific procedures for removing and replacing these parts.
9. Completing Process	9. After part(s) are replaced, do the following: • Reinstall front wheels • Lower vehicle off lift or jacks • Torque lug nuts in accordance with manufacturer's specifications (3.1.54).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could work with students on such concepts as torque, force (on part), gravity (in jacking car), power steering vs. manual steering, hydraulic pressure, friction related to wear, and ratio of turning steering wheel to turning tires. The applied mathematics teacher could cover gear ratios and their relationship to steering and U-joint orientation.

Review:

Ask students review questions such as the following:

1. For each steering part displayed, identify its name and purpose.
2. Which type of collapsible column is more common?

Application:

1. Pick one steering part (U-joint, flexible coupling, collapsible columns, steering wheel). Then assign each student a different vehicle (manufacturer, model, year), and ask students to use the appropriate resources to identify the correct procedure for removing and replacing that part. Have them compare their results and determine similarities and differences. Repeat the assignment for each steering part.

2. As students practice inspecting and replacing U-joint(s), flexible coupling(s), collapsible columns, and steering wheels, quiz them individually on the process (e.g., ask them to point out damaged parts and explain how they identified them).

Evaluation:

√ The student will inspect and replace steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.32.

Competency 3.1.32: Inspect and replace steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels.

Performance Checklist

In inspecting and replacing steering shaft U-joint(s), flexible coupling(s), collapsible columns, and steering wheels., the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate diagram for removal and replacement of each part	☐	☐	☐	☐	☐
4. Inspected each of the following parts according to standard procedure:					
a. Steering shaft	☐	☐	☐	☐	☐
b. Flexible coupling	☐	☐	☐	☐	☐
c. Collapsible column	☐	☐	☐	☐	☐
d. Steering wheel	☐	☐	☐	☐	☐
5. Accurately identified all parts needing to be replaced	☐	☐	☐	☐	☐
6. Lifted car according to standard procedure	☐	☐	☐	☐	☐
7. Replaced each part in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Reinstalled front wheels	☐	☐	☐	☐	☐
9. Lowered vehicle off lift or jacks according to standard procedure	☐	☐	☐	☐	☐
10. Torqued lug nuts to proper tightness	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.38: Adjust front and rear wheel camber on suspension systems with camber adjustments
Competency 3.1.39: Check front and rear wheel camber on adjustable and non-adjustable suspension systems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Correct front and rear wheel camber problems on adjustable and non-adjustable suspension systems
Criteria:	In accordance with the criteria in the checklist for Competencies 3.1.38/ 3.1.39

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when correcting front and rear wheel camber problems on adjustable and non-adjustable suspension systems. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Display transparency and/or distribute handouts showing extreme examples of 0° camber, positive camber, and negative camber.

2. Ask students whether they have ever seen cars with wheels like those shown!

3. Show students tires with wear caused by improper camber adjustments.

References:

Service manuals; technical service bulletins (TSBs); wheel alignment specifications manual. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Concept of Camber	2. *Camber* is the tilt of the top of the tire in relationship to the bottom of the tire. • 90° = 0° camber • Inward tilt = negative camber • Outward tilt = positive camber **Key Point:** Manufacturers often build some degree of camber (usually positive) into their vehicles to compensate for load.
3. Factors That May Affect Camber	3. Possible factors: • Incorrect tire pressure • Incorrect ride height • Additional weight (e.g., overloaded condition) • Tire wear • Bent suspension part **Key Point:** More weight in rear affects front camber and vice versa.

Presentation Outline	Steps to Cover/Key Points to Make
4. Adjusting Front Wheel Camber on Adjustable Suspension Systems	4. Place car on alignment rack, and secure. **Key Point:** If alignment rack is not computerized, look up specifications in service manual. Attach gauges on wheels and read camber. **Key Point:** If alignment rack is computerized, you may attach gauges to all four wheels and do them simultaneously. Make adjustments in accordance with manufacturer's specifications and adjustment methods. **Key Point:** Use fender cover to protect surface of vehicle (e.g., from belt buckle)
5. Determining Cause(s) of Front Wheel Camber Problems on Non-Adjustable Suspension Systems and Needed Repairs	5. **Problem:** Worn springs **Solution**: Replace springs. **Problem:** Bent front or rear strut **Solution**: Replace strut. **Problem:** Inner unibody structure damage **Solution**: Repair or replace damaged parts (1.2.17). **Problem:** Bent rear axle (only on rear camber) **Solution:** Replace axle. **Problem:** Damaged upper and/or lower control arm **Solution:** Replace control arm. **Problem:** Bent spindle assembly **Solution:** Replace spindle.
6. Determining Causes(s) of Rear Wheel Camber Problems and Needed Repairs	6. Repeat process used for front wheel camber.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied math teacher could work with students on measurement of degrees and decimal systems. The applied science teacher could cover motion of weight transfer and cause and effect (if pressure rises, what happens?).

Review:

Ask students review questions such as the following:

1. What are the effects of camber on a vehicle?
2. Camber involves a relationship. What is that relationship?
3. What is the difference between adjustable and non-adjustable suspension systems, and how does it affect the repair procedures for camber?

Application:

1. Give students pictures showing examples of camber (without the extremes), and ask them to label each type.
2. Give students a non-adjustable suspension vehicle with camber problems, and have them identify the problem and the correct repair procedure.
3. As students practice determining camber and making adjustments/repairs in accordance with manufacturer's specifications, quiz them individually on the process (e.g., ask them to outline the process for determining camber).

Evaluation:

√ The student will correct front and rear wheel camber problems on adjustable and non-adjustable suspension systems. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.1.38/3.1.39.

Competency 3.1.38:	Adjust front and rear wheel camber on suspension systems with camber adjustments
Competency 3.1.39:	Check front and rear wheel camber on adjustable and non-adjustable suspension systems; determine needed repairs

Performance Checklist

In correcting front and rear wheel camber problems on adjustable and non-adjustable suspension systems, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate wheel alignment specifications manual	☐	☐	☐	☐	☐
4. Protected vehicle's surface using fender cover	☐	☐	☐	☐	☐
5. Placed car correctly on alignment rack	☐	☐	☐	☐	☐
6. Attached gauges to wheel(s) correctly	☐	☐	☐	☐	☐
7. Read camber accurately	☐	☐	☐	☐	☐
8. Accurately identified cause(s) of camber problem	☐	☐	☐	☐	☐
9. Determined repairs needed to correct identified problem(s)	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.40: Adjust caster on suspension systems with caster adjustments
Competency 3.1.41: Check caster on adjustable and non-adjustable suspension systems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Correct caster problems on adjustable and non-adjustable suspension systems
Criteria:	In accordance with the criteria in the checklist for Competencies 3.1.40/ 3.1.41

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when correcting caster problems on adjustable and non-adjustable suspension systems. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Display transparencies and/or distribute handouts showing extreme examples of each of the following:
   - 0° caster
   - Positive caster
   - Negative caster

References:

Service manuals; technical service bulletins (TSBs); wheel alignment specifications manual. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Concept of Caster	2. *Caster* is the tilt of the top ball joint in relationship to the bottom ball joint. • 90° = 0° caster • Tilt toward driver = negative caster • Tilt away from driver = positive caster **Key Point:** Manufacturers often build some degree of caster into their vehicles to aid in directional stability
3. Factors That May Affect Caster	3. Possible factors: • Tire wear • Bent suspension part • Worn suspension components • Frame or unibody damage

Presentation Outline	Steps to Cover/Key Points to Make
4. Adjusting Caster on Adjustable Suspension Systems	4. Place car on alignment rack, and secure. **Key Point:** If alignment rack is not computerized, look up specifications in service manual. Attach gauges on wheels and read caster. **Key Point:** If alignment rack is computerized, you may attach gauges to all four wheels and do them simultaneously. Make adjustments in accordance with manufacturer's specifications and adjustment methods. **Key Point:** Use fender cover to protect surface of vehicle (e.g., from belt buckle)
5. Determining Causes of Caster Problems on Non-Adjustable Suspension Systems and Needed Repairs	5. **Problem:** Bent front or rear strut **Solution:** Replace strut. **Problem:** Inner unibody structure damage **Solution:** Repair or replace damaged parts (1.2.17). **Problem:** Damaged upper and/or lower control arm **Solution:** Replace control arm. **Problem:** Bent front spindle **Solution:** Replace spindle.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied math teacher could work with students on measurement of degrees and decimal systems. The applied science teacher could use a gyroscope to show students the effect of improper caster and then explain why gravity affects a spinning object in this way.

Review:

Ask students review questions such as the following:

1. What are the effects of caster on a vehicle?
2. Caster involves a relationship. What is that relationship?
3. What is the difference between adjustable and non-adjustable suspensions systems, and how does it affect the repair procedures for caster?

Application:

1. Give students a non-adjustable suspension vehicle with camber problems, and have them identify the problem and the correct repair procedure.
2. As students practice determining caster and making adjustments in accordance with manufacturer's specifications, quiz them individually on the process (e.g., ask them to outline the process for determining caster).

Evaluation:

√ The student will correct caster problems on adjustable and non-adjustable suspension systems. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.1.40/3.1.41.

Competency 3.1.40: Adjust caster on suspension systems with caster adjustments
Competency 3.1.41: Check caster on adjustable and non-adjustable suspension systems; determine needed repairs

Performance Checklist

In correcting caster problems on adjustable and non-adjustable suspension systems, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate wheel alignment specifications manual	☐	☐	☐	☐	☐
4. Protected vehicle's surface using fender cover	☐	☐	☐	☐	☐
5. Placed car correctly on alignment rack	☐	☐	☐	☐	☐
6. Attached gauges to wheel(s) correctly	☐	☐	☐	☐	☐
7 Read caster accurately	☐	☐	☐	☐	☐
8. Accurately identified cause(s) of caster problem	☐	☐	☐	☐	☐
9. Determined repairs needed to correct identified problem(s)	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.42: Check and adjust front wheel toe; determine needed repairs
Competency 3.1.43: Center steering wheel
Competency 3.1.46: Check rear wheel toe; determine needed adjustments or repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check front and rear wheel toe, determine needed adjustments or repairs, and center steering wheel
Criteria:	In accordance with the criteria in the checklist for Competencies 3.1.42/3.1.43/3.1.46

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when checking front and rear wheel toe, determining needed adjustments or repairs, and centering the steering wheel. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Display new tires and tires that show toe-in/toe-out (one side worn more than the other). Ask students to describe the differences between the tires. Which are new? Which show toe-in/toe-out?

2. Describe relationship between checking wheel toe and centering steering wheel (i.e., you can check wheel toe without centering the steering wheel, but not the other way around).

3. Using chalkboard drawings or available diagrams, compare toe of front wheels to steering shaft that is not centered.

4. Discuss the importance of visually checking the steering wheel inside the vehicle to determine whether it is centered.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Place vehicle on alignment rack, and secure. Check for correct ride height (3.1.29). Check tires: size, air pressure, tread wear (3.1.50). Visually inspect parts, and replace if worn. **Key Point:** Toe-in/toe-out—tie rods are most critical to toe. Attach gauges to wheel.
3. Measuring Front Wheel Toe	3. **Measurement 1:** Measure from centerline of vehicle to centerline of front of front tire. **Measurement 2:** Measure from centerline of vehicle to centerline of back of front tire. Record measurements.
4. Checking Front Wheel Toe	4. Compare recorded measurements. If Measurement 1 is greater than Measurement 2, it is toe-out. If Measurement 1 is less than Measurement 2, it is toe-in.

Presentation Outline	Steps to Cover/Key Points to Make
5. Adjusting Front Wheel Toe	5. Adjust tie rod so both measurements are in accordance with manufacturer's specifications. **Key Point:** Ensure that adjustments are tightened to manufacturer's specifications.
6. Measuring, Checking, and Adjusting Rear Wheel Toe	6. Follow same procedure as for front wheel toe, but measuring rear tires. **Key Points:** • Must do front wheel toe before rear wheel toe. • Not all cars have adjustable rear toe.
7. Determining Needed Repairs	7. Check for the following: • Bent wheel • Bent spring • Bent axle • Bad tire
8. Inspecting Steering Wheel	8. After adjusting wheel toe, visually check the steering wheel inside the vehicle to verify whether it is centered. If not centered, rotate wheel to centered position. (This will turn front tires.) Lengthen or shorten tie rods to adjust wheel toe back to original centerline position. **Key Point:** The gauges will be back to original numbers before adjusting steering wheel. Once centered, remove vehicle from alignment rack.
9. Removing Vehicle from Alignment Rack	9. Detach gauges. Lower rack, after ensuring that there are no objects in the way.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on standard and metric measurement, reading of gauges, and steering ratios. The applied science teacher could deal with the concept of friction, its impact on parts, and the effects of lubricants.

Review:

Ask students review questions such as the following:

1. How does improper wheel toe affect handling?
2. How does wheel toe affect safety?
3. What is the relationship between checking wheel toe and centering the steering wheel?

Application:

1. Set up a vehicle with a wheel toe problem, and ask students to identify the problem and describe the repair process they would use.
2. Using the same vehicle, have teams of students check and adjust the steering wheel to center its position.
3. As students practice adjusting wheel toe, quiz them individually on the process (e.g., ask them to demonstrate and verify their measurements).

Evaluation:

√ The student will check front and rear wheel toe, determine needed adjustments or repairs, and center steering wheel. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.1.42/3.1.43/3.1.46.

Competency 3.1.42: Check and adjust front wheel toe; determine needed repairs
Competency 3.1.43: Center steering wheel
Competency 3.1.46: Check rear wheel toe; determine needed adjustments or repairs

Performance Checklist

In checking front and rear wheel toe, determining needed adjustments or repairs, and centering steering wheel, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed vehicle on alignment rack securely	☐	☐	☐	☐	☐
4. Eliminated other possible causes of problems (incorrect ride height, wrong tire size, worn parts, etc.)	☐	☐	☐	☐	☐
5. Attached gauges securely to wheels	☐	☐	☐	☐	☐
6. Measured front toe accurately	☐	☐	☐	☐	☐
7. Measured rear toe (if applicable) accurately	☐	☐	☐	☐	☐
8. Adjusted front toe in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Adjusted rear toe (if applicable) in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
10. Determined needed repairs for non-adjustable rear toe	☐	☐	☐	☐	☐
11. Visually checked alignment of steering wheel	☐	☐	☐	☐	☐
12. Rotated steering wheel to center position	☐	☐	☐	☐	☐
13. Readjusted wheel toe by lengthening or shortening tie rods	☐	☐	☐	☐	☐
14. Removed vehicle from alignment rack safely	☐	☐	☐	☐	☐
15. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.44: Identify toe-out-on-turns (turning radius) problems; determine needed repairs

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Identify toe-out-on-turns (turning radius) problems, and determine needed repairs

Criteria: In accordance with the criteria in the checklist for Competency 3.1.44

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when identifying toe-out-on-turns (turning radius) problems and determining needed repairs. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Provide students with a handout that shows toe-out-on-turns and degree differences.
2. Explain that the major purpose for having the correct turning radius is to have the front wheels pivot around a common center.

References:

Service manuals; technical service bulletins (TSBs); wheel alignment guide. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Place vehicle on alignment rack and secure.
3. Identifying Suspension Damage	3. Turn wheels on radius plates, and compare readings on plate. If readings are the same, there is no suspension damage. If readings are not the same, need to determine cause of suspension damage.
4. Determining Needed Repairs	4. Possible problems/repairs: • Bent tie rod (would cause tie rod to shorten)—replace • Bent spindle—replace • Bent steering arm—replace • Bent strut—replace **Key Points:** • Be sure to check parts on both sides of vehicle. • In general, any suspension part that is damaged must be replaced. • After bent steering arm is replaced, will need to check steering ratio.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on steering ratios and on reading and comparing readings for radius plates. The applied science teacher could cover lubrication and how it affects wear.

Review:

Ask students review questions such as the following:

1. What are the possible causes of turning radius problems?
2. What effect does the turning radius have on wheel toe?

Application:

1. Have pairs of students change the wheel toe and then determine the effect of the change on the turning radius.
2. Provide vehicles with turning radius problems, and have teams of students diagnose the problem and identify the repair needed.

Evaluation:

√ The student will identify toe-out-on-turns (turning radius) problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.44.

Competency 3.1.44: Identify toe-out-on-turns (turning radius) problems; determine needed repairs

Performance Checklist

In identifying toe-out-on-turns (turning radius) problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed vehicle on alignment rack securely	☐	☐	☐	☐	☐
4. Read radius plates accurately	☐	☐	☐	☐	☐
5. Identified any suspension parts that were damaged and need to be replaced	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.45: Identify SAI (steering axis inclination)/KPI (king pin inclination) problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Identify SAI problems, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.45

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when identifying SAI problems and determining needed repairs. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Ask students to brainstorm ideas about the purpose of the steering axis inclination angle. Ask guiding questions to help them come up with the following purposes:
    - To reduce the need for excessive camber
    - To provide a pivot point around which the wheel will turn, producing easy steering
    - To aid steering stability
    - To lessen tire wear
    - To provide directional stability
    - To distribute the weight of the vehicle more evenly on tire contact
2. In most vehicles today, you will find steering axis inclination (SAI)—the focus of this CDG. You will find king-pin inclination(KPI) in race cars and large, heavy-duty trucks.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Place vehicle on alignment rack. Check ride height (3.1.29) Check tires: size, air pressure, tread wear (3.1.50). Visually inspect parts, and replace if worn. Attach gauges to front wheels. **Key Point:** SAI/KPI are for front wheels only.
3. Checking SAI	3. *SAI* refers to the angle between the true vertical of the wheel and the centerline of the ball joints. Read alignment machine for degree of angle. Compare actual angle with manufacturer's specifications.
4. Determining Needed Repairs	4. If spindle is bent, it will need to be replaced because it is non-adjustable. Most of the time if SAI is not within manufacturer's specifications, it is unlikely that the only damage is a bent spindle, and you need to look for other damage (e.g., check upper and lower ball joints).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can work with students on locating and interpreting needed information in specifications manuals. The applied mathematics teacher could cover measuring angles and reading gauges. The applied science teacher could provide lessons on how the weight of the vehicle on the tires affects wear (friction) and weight transfer.

Review:

Ask students review questions such as the following:

1. What effect does improper SAI have on a vehicle?
2. What effect does SAI have on tire wear?
3. How should you correct improper SAI?

Application:

1. Show students a bent spindle, and ask them to list the problems that would occur.
2. Provide students with two spindles—one new and one bent—and ask them to compare the two by measuring SAI and then explain their findings.

Evaluation:

√ The student will identify SAI problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.45.

Competency 3.1.45: Identify SAI (steering axis inclination)/KPI (king pin inclination) problems; determine needed repairs

Performance Checklist

In identifying SAI problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed vehicle on alignment rack securely	☐	☐	☐	☐	☐
4. Eliminated other possible causes of problems (incorrect ride height, wrong tire size, worn parts, etc.)	☐	☐	☐	☐	☐
5. Attached gauges securely to wheels	☐	☐	☐	☐	☐
6. Correctly determined inclination angle from reading on alignment machine	☐	☐	☐	☐	☐
7. Compared actual inclination angle to manufacturer's specifications	☐	☐	☐	☐	☐
8 Determined needed repairs (e.g., bent spindle replacement)	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 3.1.47: Identify thrust angle problems; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Identify thrust angle problems, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.47

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when identifying thrust angle problems and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. The rear tires should follow the same path as that of the front tires. This is known as thrust angle. If the rear tires do not follow the same path as the front tires, you have a thrust angle problem.
2. Discuss the relationship between wheel toe and thrust angle.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Place vehicle on alignment rack. Check ride height (3.1.29) Check tires: size, air pressure, tread wear (3.1.50). Attach gauges to all four wheels. Check front and rear wheel toe, and adjust as needed (3.1.42/3.1.43/3.1.46).
3. Determining Needed Repairs	3. Need to identify problems that could make thrust angle other than 0°. **Key Point:** Most suspension system parts that are worn or damaged ***must*** be replaced due to liability issues. Rear thrust angle problems/repairs: • Broken rear spring or centerpin—replace • Damaged rear control arm(s)—replace • Toe-in/toe-out problems—adjust to manufacturer's specifications Front thrust angle problems/repairs: • Damaged control arm—replace • Bent wheel—replace • Bent spindle—replace • Bent strut—replace • Bent frame—straighten

Presentation Outline	Steps to Cover/Key Points to Make
4. Returning Thrust Angle to 0°	4. Adjust the correct wheel toe to the centerline of the car. **General Rule of Thumb:** If the wheel toe is correct, the wheels should be centered to the centerline of the vehicle giving a thrust angle of 0°.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on locating and interpreting information in specifications manuals. The applied mathematics teachers could help students with measuring toe. The applied science teacher could provide lessons on friction (contact of tire and road).

Review:

Ask students review questions such as the following:

1. What effect does improper thrust angle have on steering?
2. What is the relationship between checking wheel toe and thrust angle?
3. How does thrust angle affect vehicle operation safety?

Application:

1. Provide students with teacher-prepared diagrams of thrust angle problems, and have them identify each problem.
2. Set up a vehicle with a thrust angle problem, and ask students to identify the problem and describe the repair process they would use.

Evaluation:

√ The student will identify thrust angle problems and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.47.

Competency 3.1.47: Identify thrust angle problems; determine needed repairs

Performance Checklist

In identifying thrust angle problems and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed vehicle properly on alignment rack	☐	☐	☐	☐	☐
4. Eliminated other possible causes of problems (incorrect ride height, wrong tire size, worn parts, wheel toe, etc.)	☐	☐	☐	☐	☐
5. Attached gauges securely to wheels	☐	☐	☐	☐	☐
6. Correctly identified cause(s) of thrust angle problems	☐	☐	☐	☐	☐
7. Determined repairs needed to correct identified problems	☐	☐	☐	☐	☐
8. Adjusted the corrected wheel toe to the centerline of the vehicle (thrust angle)	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________ **Date**______________

Competency 3.1.48: Check for front wheel setback; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check for front wheel setback, and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.48

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when checking for front wheel setback and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When checking front wheel setback, there is usually another problem or some other damage. This is not something that is routinely done.
2. A collision could cause front wheel setback, but another common cause would be hitting a curb.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Place vehicle on alignment rack (optional) or on level ground.
3. Determining Front Wheel Setback	3. Refer to manufacturer's specifications to determine measuring point on unibody or frame. Measure from lower ball joint to manufacturer-specified measuring point on same side as ball joint. Record measurements. Repeat for other front tire. Compare recorded measurements to manufacturer's specifications. If measurements are not equal, there's a problem.
4. Determining Problems and Needed Repairs	4. Possible problems/repairs: • Bent control arm—replace • Bent frame—straighten • Bent spindle—replace • Bent strut—replace

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on making accurate measurements. The applied communications could work with students on locating and interpreting information in specifications manuals.

Review:

Ask students review questions such as the following:

1. What are potential causes of front wheel setback?
2. What possible repairs must be made when dealing with front wheel setback?
3. When is it appropriate to check front wheel setback?

Application:

1. Provide students with teacher-prepared diagrams of wheel toe (in/out), thrust angle, and front wheel setback, and have them identify each.
2. Provide students with vehicles, and have them practice measuring from lower ball joint to specified measuring point on frame.

Evaluation:

√ The student will check for front wheel setback and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.48.

Competency 3.1.48: Check for front wheel setback; determine needed repairs

Performance Checklist

In checking for front wheel setback and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed vehicle properly on alignment rack or on level ground	☐	☐	☐	☐	☐
4. Correctly identified manufacturer-specified measuring point on frame using appropriate frame manual	☐	☐	☐	☐	☐
5. Accurately measured from ball joint to specified measuring point on same side as ball joint	☐	☐	☐	☐	☐
6. Recorded measurements accurately	☐	☐	☐	☐	☐
7. Compared recorded measurements to manufacturer's specifications	☐	☐	☐	☐	☐
8. Correctly identified cause(s) of front wheel setback	☐	☐	☐	☐	☐
9. Identified repairs needed to correct identified setback problem	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**____________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.49: Diagnose tire wear patterns; determine needed repairs
Competency 3.1.50: Inspect tires; identify direction of rotation; check and adjust air pressure

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Inspect and diagnose tires, and determine needed adjustments and repairs

Criteria: In accordance with the criteria in the checklist for Competencies 3.1.49/3.1.50

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when inspecting and diagnosing tires and determining needed adjustments and repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Tires serve a variety of purposes:
   - Carry weight of vehicle
   - Transfer braking and driving torque to the road
   - Withstand side thrust over varying speeds and conditions
2. There are many tire brands, sizes, and tread patterns.
3. Rotation and air pressure directly impact the life of a tire.

References:

Service manuals; technical service bulletins (TSBs); tire manufacturers' specification. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Causes of Tire Wear	2. **Key Points:** • Before checking any problems with tires, make sure front suspension, steering, and brake systems are adjusted and working correctly. • Check manufacturer's specifications for appropriate tire size for vehicle. Possible problems/repairs: • Improper inflation—adjust pressure to manufacturer's specifications • Lack of rotation—rotate or replace, depending on severity of problem (use depth gauge to determine severity) • Misalignment—realign using alignment rack • Bad shocks—replace • Bad springs—replace • Added weight (causes tires to wear quicker)—check manufacturer's specifications for maximum weight load

Presentation Outline	Steps to Cover/Key Points to Make
3. Determining Direction of Rotation	3. There are multiple tire rotation patterns. Check tire manufacturer's specifications for best rotation pattern for specific tire. Common patterns (without spare tire): ◆ LF to RR; RR to RF; RF to LR; LR to LF ◆ LF to LR; LR to LF; RR to RF; RF to RR Common patterns (with spare tire): ◆ LF to S; S to RR; RR to RF; RF to LR; LR to LF ◆ LF to LR; LR to LF; S to RR; RR to RF; RF to S **Key Point:** Radials must be rotated from front to rear on same side only. **Code:** LF = left front LR = left rear RF = right front RR = right rear S = spare
4. Checking and Adjusting Air Pressure	4. Determine air pressure using tire gauge. Identify air pressure specified by tire manufacturer (usually found on side of tire). Compare actual air pressure with specified air pressure. Adjust as needed by adding or removing air from tire. **Key Point:** Cold weather reduces tire pressure 1 pound for every 10° drop in temperature. Check tires according to seasonal changes in temperature (mainly summer and winter).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on measuring psi and using gauges. The applied science teacher could discuss causes of wear pattern (friction—not enough air pressure makes tire hot; weight) and how temperature affects air pressure. The applied communication teacher could help students in locating and interpreting information in specifications manuals.

Review:

Ask students review questions such as the following:

1. What causes tire wear patterns?
2. How do tire rotation and air pressure (or lack thereof) affect the life of the tire?
3. What purposes do tires serve?

Application:

1. Provide students with various brands of tires and a variety of tire manufacturers' specifications, and ask them to determine the correct air pressure and rotation pattern for each brand of tire.
2. Provide students with a variety of used tires, and ask them to determine the wear pattern on each and its cause.

Evaluation:

√ The student will inspect and diagnose tires and determine needed adjustments and repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.1.49/3.1.50.

Competency 3.1.49: Diagnose tire wear patterns; determine needed repairs
Competency 3.1.50: Inspect tires; identify direction of rotation; check and adjust air pressure

Performance Checklist

In inspecting and diagnosing tires and determining needed adjustments and repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly identified cause of tire wear	☐	☐	☐	☐	☐
4. Identified repairs needed to correct identified tire wear problem(s)	☐	☐	☐	☐	☐
5. Identified direction of tire rotation specified by tire manufacturer	☐	☐	☐	☐	☐
6. Accurately measured tire air pressure	☐	☐	☐	☐	☐
7. Adjusted air pressure in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name________________________________**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.1: Suspension and Steering

Competency 3.1.52: Measure wheel, tire, axle, and hub runout; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Measure wheel, tire, axle, and hub runout; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.52

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when measuring wheel, tire, axle, and hub runout and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Use a suspension mock-up to demonstrate to students what happens to the rotation of a tire when the wheel rim is bent.
2. Review synonymous terms for *runout* (e.g., *wobble, shimmy, vibration*).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Lift vehicle using jack stands.
3. Measuring Runout	3. *Runout* is the measurement of the out-of-roundness of the wheel rim (causing wobble, shimmy, or vibration). It is best to check runout with a runout dial gauge, but a quick check can be done as follows: • Select a fixed object such as a 2" x 4" or a jack stand. • Place this object beside the wheel, about 1/16" away from the wheel. • Spin the wheel. If the fixed object is bumped or knocked over, there is runout.
4. Determining Needed Repairs	4. Possible problems/repairs: • Bent wheel—replace • Damaged tire/broken belt—replace tire **Key Point:** Vibration in steering means problems with front tires. Vibration in the seat of your pants means a problem with the back tires. • Bent axle—replace • Damaged hub or rotor—replace hub or turn rotor

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on the principles of cause and effect. The applied mathematics teacher could help students in using and reading a dial indicator to show rim runout.

Review:

Ask students review questions such as the following:

1. What safety precautions should be taken when jacking up a car?
2. What causes runout?
3. What effect does runout have on a tire or the handling of a vehicle?

Application:

1. Divide students into small groups, and have each group prepare a procedure sheet for determining and correcting runout.
2. Have the students trade procedure sheets among groups and review and correct the procedures.

Evaluation:

√ The student will measure wheel, tire, axle, and hub runout and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.52.

Competency 3.1.52: Measure wheel, tire, axle, and hub runout; determine needed repairs

Performance Checklist

In measuring wheel, tire, axle, and hub runout and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed vehicle securely on jack stands	☐	☐	☐	☐	☐
4. Placed appropriate fixed object 1/16" from side of wheel	☐	☐	☐	☐	☐
5. Accurately determined whether there was any runout	☐	☐	☐	☐	☐
6. Correctly identified cause(s) of runout	☐	☐	☐	☐	☐
7. Determined repairs needed to correct identified problems	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 3.1.53: Diagnose tire pull (lead) problems; determine corrective actions

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Diagnose tire pull (lead) problems, and determine corrective actions
Criteria:	In accordance with the criteria in the checklist for Competency 3.1.53

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when diagnosing tire pull (lead) problems and determining corrective actions. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Display two tires—one with a broken belt and one without a broken belt—and have students roll each one.
2. Ask students to describe the difference in how the tires roll and to brainstorm possible causes.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Diagnosing Tire Pull	2. Possible problems/repairs: • Check for broken belt: Visually check front tires. Using palm of hand on tread, check for high spots indicating broken belt, or check for indications of broken belt by measuring runout (3.1.52). **Key Point:** Radial tires contain steel belts, so if one is broken, steel may protrude through the rubber, which is a safety precaution). Repair method: Replace tire. • Check air pressure. Repair method: Adjust air pressure as needed. • Check wheel alignment (3.1.38/3.1.39, 3.1.40/3.1.41). **Key Point:** Too much camber or too much split in caster (between right and left side) can cause tire pull. **Key Point:** Car pulls to the side that has the most camber and the least caster. Repair: Align wheels as needed.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could address friction in terms of tire wear and damage. The applied communications teacher could involve students in a role-playing activity in which a "technician" presents a broken belt to a "customer" and explains the problem and its causes and effects.

Review:

Ask students review questions such as the following:

1. How can a tire be checked for a defective belt?
2. If a vehicle is pulling to one side, what could be the possible causes?
3. What safety precautions should be taken when checking tires?

Application:

1. Provide students with a selection of tires, and ask them to classify the tire quality: acceptable as is, broken belt, worn only, air pressure problem.

Evaluation:

√ The student will diagnose tire pull (lead) problems and determine corrective actions. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.1.53.

Competency 3.1.53: Diagnose tire pull (lead) problems; determine corrective actions

Performance Checklist

In diagnosing tire pull (lead) problems and determining corrective actions, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Visually checked tires for bumps, high spots, tire wear	☐	☐	☐	☐	☐
4. Used standard procedures to identify the cause of the tire pull problem, including checking for—					
a. Broken belt	☐	☐	☐	☐	☐
b. Tire pressure problem	☐	☐	☐	☐	☐
c. Wheel alignment problem	☐	☐	☐	☐	☐
5. Correctly identified cause(s) of tire pull problem	☐	☐	☐	☐	☐
6. Determined corrective actions needed	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunits 3.1/3.3: Suspension and Steering/Brakes

Competencies 3.1.54/3.3.7: Reinstall wheels and torque lug nuts according to manufacturer's specifications

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Reinstall wheels and torque lug nuts
Criteria:	In accordance with the criteria in the checklist for Competencies 3.1.54/3.3.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when reinstalling wheels and torquing lug nuts in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Display a rotor with damaged wheel stud, and ask students to brainstorm possible causes of the damage.
2. Guide brainstorming session to end with the concept of torque and the importance of specific torque.

References:

Service manuals; technical service bulletins (TSBs); torque manual. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Reinstalling Wheel	2. Vehicle should already be on jack stands. Place wheel on wheel studs with flat part of the wheel against the hub. Set lug nuts on studs.
3. Torquing Lug Nuts	3. Check manufacturer's manual for torque specifications. Select proper size socket for torque wrench (measure against lug nut). Tighten lug nuts with torque wrench to specified torque. **Key Points:** • Torque pattern is like a star. • Torque keeps the same amount of pressure on the wheel and studs. • Improper torque could warp the rotor, causing damage. • Overtorquing can break a stud or cause the lug nut to be too tight to remove. • Undertorquing can cause the wheel to be loose. Reinstall hub cap.
4. Lowering Vehicle Off Jack Stands	4. Remove jack stands. Lower vehicle, after ensuring that there are no objects in the way.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on reading the dial on a torque wrench. The applied science teacher could deal with the principles of cause and effect and the concept of friction (stripping studs).

Review:

Ask students review questions such as the following:

1. What are the potential hazards if lug nuts are improperly torqued?
2. If you use the wrong torque wrench and socket, how will this affect the customer?
3. Where should you look to find torque specifications and tightening sequences for a particular vehicle?

Application:

1. Provide students with a list of different makes and models of vehicles, and have them look up and compare the torque specifications for these vehicles.
2. Provide students with a variety of lug nuts, and have them select the proper torque wrench and socket for each lug nut.
3. Divide the class into teams, and have them compete in reinstalling a wheel. Which team best meets the performance criteria (proper procedure and torque)?

Evaluation:

√ The student will reinstall wheels and torque lug nuts. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.1.54/3.3.7.

Competencies 3.1.54/3.3.7: Reinstall wheels and torque lug nuts according to manufacturer's specifications

Performance Checklist

In reinstalling wheels and torquing lug nuts, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Placed wheel on wheel studs in proper direction	☐	☐	☐	☐	☐
3. Placed lug nuts on wheel studs	☐	☐	☐	☐	☐
4. Checked manufacturer's manual for torque specifications	☐	☐	☐	☐	☐
5. Selected torque wrench with proper socket size	☐	☐	☐	☐	☐
6. Tightened all lug nuts to specified torque	☐	☐	☐	☐	☐
7. Reinstalled hubcap (if applicable) correctly	☐	☐	☐	☐	☐
8. Removed jack stands and lowered car according to standard procedure	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.1:	Check voltages in electrical wiring circuits with a DVOM (digital volt ohmmeter)
Competency 3.2.2:	Check continuity and resistance in electrical wiring circuits and components with a DVOM (digital volt ohmmeter)

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check voltage, resistance, and amperage in electrical wiring circuits and components using a DMM
Criteria:	In accordance with the criteria in the checklist for Competencies 3.2.1/3.2.2

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when checking voltage, resistance, and amperage in electrical wiring circuits and components using a DMM. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask whether any students have ever installed a car radio and, if so, whether they followed a wiring diagram.
2. Ask students to describe different types of electricity.
3. Show students a digital multimeter (DMM)—also called a digital volt-ohm meter or digital volt ohmmeter (DVOM).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. Remember to cover test sites on electrical wire with electrical tape to prevent possible corrosion.
3. Basic Electricity/Electronic Principles	3. Types of electric current: • AC (alternating current)—current that travels in both directions • DC (direct current)—current that travels in one direction Electrical measures: • Voltage—unit for measuring electrical force or pressure • Amperage/Current—unit for measuring flow of electrons past a given point in a circuit • Resistance/Ohms—unit for measuring limits (controls) to current flow • Wattage—unit for measuring amount of work done by an electrical current (volts x amps) Complete circuit—current flows without a break (continuity) Conditions affecting normal operation: • Open circuit—a break in the circuit • Shorted circuit—allows flow around normal path or load • Grounded circuit—allows current to return to the battery before the intended load

Presentation Outline	Steps to Cover/Key Points to Make
4. Measurement of Electricity	4. Ohm's Law is the mathematical formula to show how voltage (E), amperage/ current (I), and resistance/ohms (R) work together: • $E = I \times R$ • $I = E \div R$ • $R = E \div I$
5. Digital Multimeter (DMM)	5. DMM allows technician to obtain accurate measures of circuit values: voltage, resistance/ohms, amperage. Readings (test values) are shown on the meter display as actual numbers. By comparing the values obtained to known "good" values (found in vehicle specifications manual), you can identify problems.
6. Connecting the DMM	6. Attach the lead wires in accordance with the wiring flow chart in vehicle specifications manual. **Key Points:** • Red wire lead denotes positive (hot wire). • Black wire lead denotes negative. • Remember to keep wire leads away from moving parts.
7. Checking Voltage	7. Procedure for checking resistance using DMM, including— • Make sure vehicle has power. • Test on live circuits. • Set control to desired setting (ohm, amp, resistance, and voltage). • Connect meter in parallel to circuit. Power must be on. **Key Point:** If there is no increase in numerical reading, recheck wiring flow chart or refer to repair procedures (3.2.3/3.2.4).

Presentation Outline	Steps to Cover/Key Points to Make
8. Checking Resistance	8. Procedure for checking resistance using DMM, including— ◆ Test on dead circuits. ◆ Set controls. ◆ Circuit must be isolated. Power must be off.
9. Checking Amperage	9. Procedure for checking amperage using DMM, including— ◆ Use inductive clamps in series. ◆ Set controls. ◆ Connect with inductive clamp or in series with the circuit being tested (make sure amperage rating of circuit does not exceed amperage rating of DMM). **Caution:** If amperage rating of circuit ***does*** exceed amperage rating of DMM, it could blow a fuse or damage the electrical circuits in DMM or, in severe cases, cause DMM to blow up. ◆ Power to circuit should be on after tester is connected.

> ***Note:*** The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.
>
> For example, the applied mathematics teacher could cover measuring electrical current and solving problems using Ohm's law. The applied science teacher could work with students on basic principles of electricity (volts, amps, ohms, watts, etc.).

Review:

Ask students review questions such as the following:

1. What purposes does the electrical current in a vehicle serve?
2. What is a DMM or DVOM?
3. What is an open circuit?
4. Define *continuity*.

Application:

1. Set up a vehicle with the headlights on and the engine at 2,000 RPM, and have students use DMM to check for AC voltage at the battery (max 0.4 volts AC).
2. Distribute various wiring harnesses with different problems, and ask students to identify each problem.

Evaluation:

√ The student will check voltage, resistance, and amperage in electrical wiring circuits and components using a DMM. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.2.1/3.2.2.

Competency 3.2.1:	Check voltages in electrical wiring circuits with a DVOM (digital volt ohmmeter)
Competency 3.2.2:	Check continuity and resistance in electrical wiring circuits and components with a DVOM (digital volt ohmmeter)

Performance Checklist

In checking voltage, resistance, and amperage in electrical wiring circuits and components using a DMM, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Attached DMM correctly	☐	☐	☐	☐	☐
4. Selected the correct DMM setting for the test	☐	☐	☐	☐	☐
5. Determined electrical flow using wiring flow chart	☐	☐	☐	☐	☐
6. Measured each of the following using the DMM in accordance with standard procedure:					
a. Voltage	☐	☐	☐	☐	☐
b. Resistance	☐	☐	☐	☐	☐
c. Amperage	☐	☐	☐	☐	☐
7. Obtained accurate readings	☐	☐	☐	☐	☐
8. Determined continuity	☐	☐	☐	☐	☐
9. Compared values obtained to known "good" values	☐	☐	☐	☐	☐
10. Maintained clean work environment	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.3:	Using a DVOM (digital volt ohmmeter), repair electrical circuits, wiring, and connectors according to manufacturer's specifications
Competency 3.2.4:	Inspect, test, and replace fusible links, circuit breakers, and fuses

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, test, and replace fusible links, circuit breakers, and fuses
Criteria:	In accordance with the criteria in the checklist for Competencies 3.2.3/3.2.4

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, testing, and replacing fusible links, circuit breakers, and fuses in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students if any of them have ever experienced an electrical problem in their car and, if so, what they did about it.
2. Ask students to describe what fuses are and what purposes they serve.
3. Show examples of fuses, fusible links, and circuit breakers.
4. Introduce (or reintroduce) the digital multimeter (DMM)—also called a digital volt-ohm meter or digital volt ohmmeter (DVOM)—to students (3.2.1/3.2.2).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. Remember to cover test sites on electrical wire with electrical tape or heat-shrink tape to prevent possible corrosion.
3. Locating Electrical Fault	3. To pinpoint the location of an electrical fault, you can use a DMM to test the fuses, fusible links, and circuit breakers.
4. Testing Fuses	4. Each fuse should have voltage on both sides of its metal ends. A blown fuse will only be hot on the feed side. **Key Point:** It's a good idea to check all fuses for continuity. Using DMM, attach one lead on each side of fuse. If the fuse is good, DMM will register a reading of appropriate voltage or continuity. If fuse is blown, replace it in accordance with manufacturer's specifications. Recheck circuit. If electrical fault still exists, test the fusible links (Step 4).

Presentation Outline	Steps to Cover/Key Points to Make
5. Testing Fusible Links	5. A fusible link is housed within the wiring harness itself. Refer to vehicle specifications manual flow chart for exact location. Using DMM, attach one lead on each side of fusible link. Check DMM for continuity. If there is ***no continuity***, replace the fusible link (Step 5). If there is ***continuity***, test the circuit breaker (Step 6).
6. Replacing Fusible Link	6. Replace fusible link with identical type. Cut existing fusible link out with wire splicers. Splice new fusible link by soldering connectors with a non-acid-core solder (6.7). Recheck circuit. If electrical fault still exists, test the circuit breaker (Step 6).
7. Testing Circuit Breaker	7. Identify manufacturer's specifications for circuit breaker. Use DMM to check power-in and power-out of the circuit breaker, and compare readings with specifications. Check amperage reading on circuit breaker, and compare with specifications. If readings do not match specifications, replace the circuit breaker (Step 7).
8. Replacing Circuit Breaker	8. Follow replacement procedure specified by manufacturer.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on measuring electrical current. The applied science teacher could provide lessons on the properties of soldering metals and on electrical current/flow. The applied communications teacher could help students in interpreting flow charts and locating information in specifications manuals.

Review:

Ask students review questions such as the following:

1. What is the difference between a fusible link and a fuse?
2. Why is it important to cover test sites with electrical tape or heat-shrink tape?

Application:

1. Divide students into small groups, and assign each a particular vehicle. Have each group locate and outline the specifications for circuit breakers and the procedures for replacing fusible links and circuit breakers for the assigned vehicle. Then ask students to compare results and note commonalties and differences.
2. Disable a vehicle, and have students diagnose the electrical problem in a specified amount of time.
3. As students practice removing and reinstalling fuses, fusible links, and circuit breakers, quiz them individually on the process (e.g., ask them to explain how to attach the leads to the fusible link).

Evaluation:

√ The student will inspect, test, and replace fusible links, circuit breakers, and fuses. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.2.3/3.2.4.

Competency 3.2.3: Using a DVOM (digital volt ohmmeter), repair electrical circuits, wiring, and connectors according to manufacturer's specifications

Competency 3.2.4: Inspect, test, and replace fusible links, circuit breakers, and fuses

Performance Checklist

In inspecting, testing, and replacing fusible links, circuit breakers, and fuses, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Tested each of the following in accordance with appropriate flow chart:					
a. Fuses	☐	☐	☐	☐	☐
b. Fusible links	☐	☐	☐	☐	☐
c. Circuit breaker	☐	☐	☐	☐	☐
4. Identified correct replacement part(s) to use	☐	☐	☐	☐	☐
5. Replaced part(s) in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Rechecked electrical system as needed to verify operation	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.5:	Perform battery state-of-charge test; determine needed service
Competency 3.2.8:	Perform slow/fast battery charge in accordance with manufacturer's recommendations

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform a battery state-of-charge test and slow/fast battery charge
Criteria:	In accordance with the criteria in the checklist for Competencies 3.2.5/3.2.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when performing battery state-of-charge tests and slow/fast battery charges in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain the purpose of a battery.
2. Describe what causes a battery to go dead.
3. Ask students: If the battery is dead, must it always be replaced?
4. Discuss the types of battery chargers and the differences among them.

References:

Service manuals; technical service bulletins (TSBs); battery charger manual (to avoid overcharging). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	**Steps to Cover/Key Points to Make**
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. Never charge a frozen battery. Let it thaw on its own.
3. Determining Battery Quality	3. Check the warranty. Determine the age of the battery. Visually inspect battery to determine overall condition. Check for problems such as the following— • Corrosion • Loose connections • Cracks in the case
4. Determining Amount of Charge	4. Attach DMM red (+) lead wire to positive terminal on battery. Attach DMM black (–) lead wire to negative terminal on battery. Compare DMM reading to chart to determine battery charge.

State of Charge	Battery Voltage
Fully Charged	12.6 or higher
75% Charged	12.4
50% Charged	12.2
25% Charged	12.0
Discharged	11.9 or lower

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Presentation Outline	Steps to Cover/Key Points to Make
	Disconnect negative battery cable. **Key Points:** • Can cause damage to computer components if you do not disconnect negative battery cable (3.2.6). • Loosening the positive cable first could cause an explosion. Loosen and remove positive cable last.
5. Checking Acid Level on Battery	5. **Key Point:** This does not need to be checked on maintenance-free batteries. If one or more battery cells are empty, need to replace the battery. If the fluid level is low, fill with appropriate fluid and charge the battery (Steps 6–9).
6. Connecting Battery Charger	6. Connect charger in the following order: • Attach red cable to positive terminal on battery. • Attach black cable to negative terminal on battery. Plug battery charger into appropriate power source.
7. Setting the Charger	7. To set charge, refer to chart on previous page. The rate of charge will depend on the amount of discharge (as shown on chart). If battery is completely discharged, it must be slow-charged (i.e., charged on a low setting). **Key Point:** Overcharging can cause a battery to explode.
8. Monitoring Charger	8. Check and record ammeter (amp) reading found on battery charger. After the ammeter reading has fallen to 3 amps or less—or the DMM reading is 12.6 or higher—the charger should be turned off.

Presentation Outline	Steps to Cover/Key Points to Make
9. Disconnecting Battery Charger	9. Charger must be disconnected in the following order: • Turn off power supply. • Disconnect black cable from battery. • Disconnect red cable from battery.
10. Checking Charged Battery	10. Reconnect negative cable on battery. Record DMM reading of newly charged battery. Recheck reading if battery fails.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on measuring electrical current. The applied science teacher could provide information on acid and its relation to positive and negative charges.

Review:

Ask students review questions such as the following:

1. What is a maintenance-free battery?
2. How do you know when the battery is charged?
3. Why is it important not to overcharge a battery?
4. What could happen if the negative battery cable is not disconnected?

Application:

1. Provide students with two batteries—one completely charged and one completely discharged—and have them compare the DMM readings on each.
2. As students practice charging a battery, quiz them individually on the process (e.g., ask them to explain how they decided whether to slow- or fast-charge the battery).

Evaluation:

√ The student will perform a battery state-of-charge test and slow/fast battery charge. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.2.5/3.2.8.

Competency 3.2.5: Perform battery state-of-charge test; determine needed service
Competency 3.2.8: Perform slow/fast battery charge in accordance with manufacturer's recommendations

Performance Checklist

In performing a battery state-of-charge test and slow/fast battery charge, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Accurately determined present battery charge using DMM	☐	☐	☐	☐	☐
4. Disconnected battery cables in correct order	☐	☐	☐	☐	☐
5. Attached charger to battery in correct sequence	☐	☐	☐	☐	☐
6. Set charger to correct charge	☐	☐	☐	☐	☐
7. Monitored the charging process and amount of charge	☐	☐	☐	☐	☐
8. Disconnected charger as soon as charging was complete	☐	☐	☐	☐	☐
9. Accurately recorded DMM reading after charge was complete	☐	☐	☐	☐	☐
10. Maintained clean work environment	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name ____ **Date** ______________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.6: Inspect, clean, and replace battery

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, clean, and replace a battery
Criteria:	In accordance with the criteria in the checklist for Competency 3.2.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, cleaning, and replacing batteries in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain the purpose of the battery.
2. Show photos of a damaged battery, and ask students to brainstorm causes of corrosion.
3. Explain how often a battery should be inspected and cleaned and how often, in general, it should need to be replaced.
4. Describe different types of batteries: maintenance-free, dry-cell, etc.
5. Discuss different brands of batteries and whether one brand is better than others.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Inspecting the Battery	2. Check for— • Age • Condition • Visual damage (e.g., marks, cracks) • Terminal damage (e.g., corrosion)
3. Disconnecting Battery Cables	3. **Key Point:** Be sure to follow all safety procedures (e.g., remove all jewelry and wear safety glass and latex gloves). Loosen and remove negative cable first. **Key Point:** Loosening the positive cable first could cause an explosion. Loosen and remove positive cable second.
4. Cleaning Battery Components	4. Three basic components: • Terminal • Battery case • Cable connectors

Presentation Outline	Steps to Cover/Key Points to Make
	Mix equal parts of baking soda and water. Apply mixture to all components with an acid-type brush (firm-tipped). Reapply mixture as many times as necessary until all components are clean. Rinse with plain water. After washing, clean terminals and connectors with a wire brush.
5. Disconnecting Battery Tie-Downs	5. Types of tie-downs: • Tie-down at base of battery • Connective arm with rod support to frame Remove tie-downs in accordance with procedure for particular type.
6. Removing Battery	6. Lift battery out of vehicle carefully using both hands. Avoid touching terminals.
7. Inspecting and Cleaning Battery Tray	7. Check for battery acid on tray. Remove battery acid by cleaning the tray with an acid brush and a baking soda/water solution. Inspect tray for corrosion, and replace if necessary.
8. Checking and Recording Cold Cranking Amps (CCA)	8. CCA is found in standard references (e.g., owner's manual, battery retailer's manual). **Key Point:** When replacing a battery, make sure that the new battery has a value (CCA) equal to or greater than the original-equipment battery.
9. Installing New Battery	9. **Key Point:** Mark present date on new battery. Place battery onto clean tray, and secure tie-down. Secure positive cable first. Secure negative cable second.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could work with students on chemical reactions, causes of corrosion, properties of cleaning solutions (baking soda/water), electrical charge, and why improper battery hook-up can cause explosions. The applied communications teacher could work with students on locating and interpreting information in reference manuals.

Review:

Ask students review questions such as the following:

1. Why is it so important to remove jewelry when working under the hood of a car?
2. What purposes does the battery serve?
3. What different types of batteries are there?
4. Why should you disconnect the negative cable before the positive cable?

Application:

1. Ask students to prepare a checklist of the steps in the entire battery cleaning and changing process.
2. Provide students with case studies describing particular models and makes of cars, and ask them to use reference materials (e.g., vehicle manufacturer's manual) to locate the appropriate battery for each car.
3. As students practice cleaning, removing, and replacing batteries, quiz them individually on the process (e.g., ask them to describe the battery removal process they used).

Evaluation:

√ The student will inspect, clean, and replace a battery. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.2.6.

Competency 3.2.6: Inspect, clean, and replace battery

Performance Checklist

In inspecting, cleaning, and replacing a battery, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Performed complete visual inspection of the battery	☐	☐	☐	☐	☐
5. Correctly identified the following:					
a. Location of battery	☐	☐	☐	☐	☐
b. Age of battery	☐	☐	☐	☐	☐
c. Condition of battery	☐	☐	☐	☐	☐
d. Battery damage (marks, cracks)	☐	☐	☐	☐	☐
e. Corrosion on terminals	☐	☐	☐	☐	☐
6. Disconnected battery cables in correct order	☐	☐	☐	☐	☐
7. Cleaned battery components thoroughly in accordance with standard procedure	☐	☐	☐	☐	☐
8. Removed battery tie-down in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Removed battery carefully, without touching terminals	☐	☐	☐	☐	☐
10. Inspected battery tray for corrosion	☐	☐	☐	☐	☐
11. Removed all corrosion from battery tray using appropriate solution and brush	☐	☐	☐	☐	☐
12. Replaced battery in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
13. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.10: Inspect, clean, and repair or replace battery cables, connectors, and clamps

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, clean, and repair or replace battery cables, connectors, and clamps
Criteria:	In accordance with the criteria in the checklist for Competency 3.2.10

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when inspecting, cleaning, and repairing or replacing battery cables, connectors, and clamps. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Show a damaged cable, and ask students to brainstorm the purposes of battery cables and what happens to those purposes when the cable is damaged?
2. Explain why cables come in different sizes.
3. Describe where cables are attached to vehicle.
4. Show various types of cables, connectors, and clamps.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Inspect battery (3.2.6). Check cables for burns. Check connectors for corrosion. Check housing for cracks or cuts. Record mounting locations. Disconnect and clean battery cables (3.2.6).
3. Removing Damaged Cables	3. Disconnect negative cable from engine block or frame. Disconnect positive cable from starter solenoid. **Key Point:** It is important to replace all wires that are attached at the same location.
4. Installing New Cables	4. Cables ***must*** be connected in the following order: Denote positive cable with red tape (unless otherwise noted), and connect to starter solenoid. Denote negative cable with black tape (unless otherwise noted), and connect to engine block or frame.
5. Connecting New Cables to Battery	5. Secure positive cable to terminal first. Secure negative cable to terminal second.

Presentation Outline	Steps to Cover/Key Points to Make
6. Repairing Cables, Connectors, and Clamps	6. Cables are not usually repaired on newer vehicles (models after 1992) because— • This can alter the current, which affects the computer readings • It's not as reliable as replacing with a new cable • The repair/replacement costs are comparable.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover corrosion, electrical charge, current capacity, and properties of chemical solution (baking soda/water). The applied communications teacher could work with students on locating and interpreting information in reference manuals.

Review:

Ask students review questions such as the following:

1. Why is it so important to attach the positive cable to the starter solenoid.
2. Why is it considered to be better to replace the cable rather than repairing it.
3. Why is baking soda and water used as the cleaning solution?

Application:

1. Ask students to prepare a checklist of the steps in the entire procedure for inspecting, cleaning, and repairing or replacing battery cables, connectors, and clamps.
2. Provide students with corroded components, and have them thoroughly clean each using the correct solution and procedure.
3. As students practice changing battery cables, quiz them individually on the process (e.g., ask them to review the correct order for removing and reinstalling cables).

Evaluation:

√ The student will inspect, clean, and repair or replace battery cables, connectors, and clamps. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.2.10.

Competency 3.2.10: Inspect, clean, and repair or replace battery cables, connectors, and clamps

Performance Checklist

In inspecting, cleaning, and repairing or replacing battery cables, connectors, and clamps, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Inspected battery, cables, connector, and mounting locations for damage or corrosion	☐	☐	☐	☐	☐
5. Disconnected battery cables in correct order	☐	☐	☐	☐	☐
6. Cleaned cables thoroughly in accordance with standard procedure	☐	☐	☐	☐	☐
7. Installed new cables following established procedure	☐	☐	☐	☐	☐
8. Connected new cables in correct order	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.11: Inspect alignment, adjust, and replace generator (alternator) drive belts, pulleys, and fans

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect the alignment of generator (alternator) drive belts, pulleys, and fans, and adjust or replace them as needed
Criteria:	In accordance with the criteria in the checklist for Competency 3.2.11

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when inspecting the alignment of generator (alternator) drive belts, pulleys, and fans and adjusting or replacing as needed. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain the types of problems that can occur when generator (alternator) belts are worn or damaged.
2. Show a worn V-belt and serpentine belt.
3. Ask students to brainstorm possible causes of damage to belts, pulleys, and fans.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. Have hair tied back at all times when working with moving parts
3. Checking V-Belts	3. **Key Point:** V-belts control separate components of the engine. Look for dry rot, cracks, splits, fraying. If damage is found, belt will need to be replaced (Step 4). Check tension using a belt tension gauge to determine whether the belt has been stretched. General rules of thumb for using belt tension gauge: • If free span between pulleys is less than 12", deflection should be 1/8" to 1/4". • If free span between pulleys is more than 12", deflection should be 1/8" to 3/8". **Key Point:** When belts are stretched, they will cause a squealing noise. If the belt is stretched, it may need to be adjusted (Step 3).

Presentation Outline	Steps to Cover/Key Points to Make
4. Adjusting V-Belts	4. Locate belt adjustment specifications in vehicle manufacturer's specifications. Loosen the bolt. Adjust appropriate component until belt becomes taut. Retighten the bolt. Recheck the tension. **Key Point:** When adjusting a belt, avoid overtightening, which can cause belt damage.
5. Replacing V-Belts	5. To replace one V-belt, others may have to first be removed. The replacement procedure is almost the same as the adjustment procedure (Step 3), with one difference: • After loosening the bolt, remove the bolt completely and install a new one.
6. Checking Serpentine Belts	6. **Key Point:** Serpentine belts replaced the earlier V-belts and control the entire engine. Look for dry rot, cracks, splits, fraying. Some manufacturers say that it is okay for minor cracks to appear in the belt, so you need to refer to manufacturer's specifications manual. Serpentine belts cannot be adjusted to eliminate squealing; they must be replaced (Step 6). Check pulley alignment. **Key Point:** Pulley alignment is critical. If it is not aligned, it will cause wear to the belt and excessive squealing noise.

Presentation Outline	Steps to Cover/Key Points to Make
7. Replacing Serpentine Belts	7. If possible, record location and mounting route of serpentine belt. Locate belt tensioner using manufacturer's specifications manual. Loosen the belt tensioner using appropriate tool, and remove bolt. **Key Point:** Belt tensioner is spring loaded, so use caution when removing. Replace belt in accordance with manufacturer's specifications. Recheck alignment of belts to ensure it is correct. If not, the pulley should be checked (Step 7).
8. Inspecting Drive Pulleys	8. Check drive pulley for damage. For example, the pulley may be bent as a result of a collision.
9. Replacing Drive Pulleys	9. Replace pulley and torque in accordance with manufacturer's specifications.
10. Inspecting Fans	10. Inspect fan for visible damage (e.g., could be bent due to collision). If damaged, it will need to be replaced (Step 7).
11. Replacing Fans	11. Remove mounting bolts and fan in accordance with manufacturer's specifications. Replace fan and torque mounting bolts in accordance with manufacturer's specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on friction and torque related to belts and pulleys.

Review:

Ask students review questions such as the following:

1. What is the difference between V-belts and serpentine belts?
2. What should you look for when inspecting drive belts?
3. If a belt is squealing, should it always be replaced?
4. What is the procedure for adjusting a V-belt?

Application:

1. Set up a variety of vehicles, and have students determine which belts need to be replaced?
2. As students practice adjusting and replacing belts, pulleys, and fans, quiz them individually on the process (e.g., ask them to point out specific damage and misalignment problems they located).

Evaluation:

√ The student will inspect the alignment of generator (alternator) drive belts, pulleys, and fans and adjust or replace them as needed. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.2.11.

Competency 3.2.11: Inspect alignment, adjust, and replace generator (alternator) drive belts, pulleys, and fans

Performance Checklist

In inspecting the alignment of generator (alternator) drive belts, pulleys, and fans and adjusting or replacing them as needed, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Visually inspected belts, pulleys, and fans for damage	☐	☐	☐	☐	☐
4. Determined whether any belts, pulleys, or fans needed to be adjusted or replaced	☐	☐	☐	☐	☐
5. Made the following adjustments/replacements as needed:					
a. Adjusted V-belt(s) in accordance with standard procedure	☐	☐	☐	☐	☐
b. Adjusted V-belt(s) to proper tension	☐	☐	☐	☐	☐
c. Replaced belt(s) in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
d. Replaced drive pulley(s) in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
e. Replaced fan(s) in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
6. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.13:	Remove and replace head lamp/light, parking/tail lamp/light, stop lamp/light, flashers, turn-signals, and backup lamp/light; check operation
Competency 3.2.14:	Inspect, replace, and aim head lamp/light bulbs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Replace vehicle lamps/lights and check their operation; and inspect, replace, and aim head lamp/light bulbs
Criteria:	In accordance with the criteria in the checklist for Competencies 3.2.13/ 3.2.14

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when replacing vehicle lamps/lights and checking their operation; and inspecting, replacing, and aiming head lamp/light bulbs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students: Why, if we can use hand signals, do we need turn signals and stop lamps/lights?

2. Explain how poorly aimed lights affect visibility.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Removing Vehicle Lamp Assemblies	2. **Note:** Depending on the make of the vehicle, other bolt-on parts may need to be removed first for access to the lamp. Unbolt or unscrew the lamp assembly, disconnect the wiring, and remove assembly. Inspect for possible hidden damage to mounting brackets. Repair damage as necessary in accordance with standard procedure.
3. Replacing Bulbs	3. Replace bulbs as needed. **Key Point:** When replacing the head lamp bulb, do not touch the bulb with your bare hands, because the oil in your skin could cause the bulb to burn out.
4. Replacing Vehicle Lamp Assemblies	4. Reinstall or replace lamp assembly in accordance with manufacturer's specifications. Attach wires. **Key Point:** Be sure to check for operation before securing the lamp assembly.
5. Aiming Head Lamps	5. Check manufacturer's specifications for proper height and direction of beam. Adjust screws in accordance with specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the principles of lighting and diffusion of light. The applied mathematics teacher could work with students on angles in relationship to headlight adjustment.

Review:

Ask students review questions such as the following:

1. What is the procedure for aiming lights?

2. Why is it important not to touch a head lamp bulb while replacing it?

3. Why should you check the operation of the lamp before securing the part?

Application:

1. As students practice replacing various lamps on an assigned vehicle, quiz them individually on the processes (e.g., ask them to describe other bolt-on parts that had to be removed for access to a given lamp).

2. As students practice aiming head lamps, quiz them individually on the process (e.g., ask them to point out where they found the specifications for height and direction of beam).

Evaluation:

√ The student will replace vehicle lamps/lights and check their operation; and inspect, replace, and aim head lamp/light bulbs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.2.13/3.2.14.

Competency 3.2.13: Remove and replace head lamp/light, parking/tail lamp/light, stop lamp/light, flashers, turn-signals, and backup lamp/light; check operation

Competency 3.2.14: Inspect, replace, and aim head lamp/light bulbs

Performance Checklist

In replacing vehicle lamps/lights and checking their operation; and inspecting, replacing, and aiming head lamp/light bulbs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Removed any bolt-on parts preventing access to the lamp	☐	☐	☐	☐	☐
4. Unbolted and carefully removed lamp assembly	☐	☐	☐	☐	☐
5. Identified any hidden damage on the mounting surface	☐	☐	☐	☐	☐
6. Replaced bulb if necessary	☐	☐	☐	☐	☐
7. Ensured that head lamp bulb was not touched with bare hands	☐	☐	☐	☐	☐
8. Reinstalled or replaced lamp assembly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Checked lamp operation before securing assembly	☐	☐	☐	☐	☐
10. Secured lamp assembly	☐	☐	☐	☐	☐
11. Aimed and aligned lamp in accordance with height and direction specifications	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**________________

Unit 3: Mechanical and Electrical Components

Subunit 3.2: Electrical

Competency 3.2.19: Check operation of windshield wiper/washer system
Competency 3.2.20: Check operation of power side windows and power tailgate window

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Check the operation of the windshield wiper/washer system, power side windows, and power tailgate window

Criteria: In accordance with the criteria in the checklist for Competencies 3.2.19/ 3.2.20

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking the operation of windshield wiper/washer systems, power side windows, and power tailgate windows in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students if any of them have had experience with a power window or power unit that did not work. What had to be done to fix it?

2. Explain how a power window works.

3. Describe the purpose of a test light.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Test Light	2. A test light provides a quick and easy way to check a circuit for power or continuity. Types: • Circuit-powered test light—uses circuit voltage to illuminate tester bulb • Self-powered test light (continuity tester)—uses own power source to check continuity Most test lights have a sharp probe for touching conductors and an alligator clip for grounding. **Key Point:** Remember to cover test sites on electrical wire with electrical tape or heat-shrink tape to prevent possible corrosion.
3. Checking Windshield Wiper Motor or Windshield Washer System	3. Make sure vehicle has power and windshield wiper or washer motor is on. Attach lead wire from test light to ground using alligator clip. Touch test light probe to windshield wiper or washer motor plug. If the test light comes on, it indicates that there is power to the windshield wiper or washer motor.

Presentation Outline	Steps to Cover/Key Points to Make
	If there is ***power*** to the motor but the motor doesn't work, it may need to be replaced. If there is ***no power*** to the motor, the fuses, fusible links, or circuit breakers need to be repaired/replaced (3.2.3/3.2.4).
4 Checking Power Side and Tailgate Windows	4. Make sure vehicle has power. Check operating switches as follows: • Attach lead wire from test light to ground using alligator clip. • Touch test light probe to operating switch, and watch to see whether the light comes on. • If there is ***no power*** to the operating switch, the fuses, fusible links, or circuit breakers need to be repaired/replaced (3.2.3/3.2.4). • If there is ***power*** to the switch but the windows don't operate, you need to check the motor. Check the motor as follows: • Attach lead wire from test light to ground using alligator clip. • Touch test light probe to window motor plug, and watch to see whether the light comes on. • If there is ***power*** to the motor but the motor doesn't work, it may need to be replaced. • If there is ***no power*** to the motor, the fuses, fusible links, or circuit breakers need to be repaired/replaced (3.2.3/3.2.4).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can cover testing electricity and its paths. He/she could also provide lessons on amp draw and how it can change as a result of wear and tear on parts—what's good and what's not.

Review:

Ask students review questions such as the following:

1. What are the differences between manual and power windows?
2. What can cause a power unit to fail?
3. What does it mean when the test light comes on?

Application:

1. Disable a power unit, and have students diagnose the problem.
2. As students practice checking the operation of various power units, quiz them individually on the process (e.g., ask them to describe the procedure they are following).

Evaluation:

√ The student will check the operation of the windshield wiper/washer system, power side windows, and power tailgate window. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.2.19/3.2.20.

Competency 3.2.19: Check operation of windshield wiper/washer system
Competency 3.2.20: Check operation of power side windows and power tailgate window

Performance Checklist

In checking the operation of the windshield wiper/washer system, power side windows, and power tailgate window, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Attached test light correctly	☐	☐	☐	☐	☐
4. Tested power units in the appropriate order	☐	☐	☐	☐	☐
5. Tested each power unit with the test light according to standard procedure	☐	☐	☐	☐	☐
6. Correctly pinpointed the source of the problem (motor, switch, fuses, etc.)	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____ **Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.3: Brakes

Competency 3.3.4:	Bleed (manual, pressure, vacuum, or surge) and/or flush hydraulic brake system in accordance with manufacturer's specifications
Competency 3.3.5:	Pressure-test brake hydraulic system; determine needed repairs

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Bleed, flush, and pressure-test a brake hydraulic system; and determine needed repairs
Criteria:	In accordance with the criteria in the checklist for Competencies 3.3.4/3.3.5

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when bleeding, flushing, and pressure-testing brake hydraulic systems and determining needed repairs. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. You can pressure-test system by manually pushing on the brake to check for fluid leaks.
2. When there is air in the hydraulic system, it must all be removed. This is done by a process called *bleeding*.
3. Because air can be compressed, it will not allow the hydraulic pressure to remain consistent and could cause system failure.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safety & Vehicle Care Practices	2. Improper storage and handling of brake fluid can be dangerous (e.g., can cause injury to skin or blindness). Brake fluid can damage painted surfaces, so protect these areas accordingly.
3. Pascal's Law/Hydraulics Fundamentals	3. Pascal stated that liquids cannot be compressed in a confined area, but they can be pressurized, and this pressure is transmitted equally in all directions. Thus, hydraulics can be used to increase or decrease force or motion. Air, since it is compressible, is the greatest enemy of a hydraulic system. Hydraulic pressure cannot be transmitted if there is air in the system. The brake pedal will feel "spongy," and a serious condition arises. To remove the air, you must *bleed* it out.
4. Manual Bleeding	4. Most commonly, you will need a helper. Bleed only one wheel at a time, following the manufacturer's sequence. Place bleeder jar and hose at bleeder screw.

Presentation Outline	Steps to Cover/Key Points to Make
	Have assistant "pump" pedal slowly several times to force air to the bleeder screw, and then hold pedal down. Open bleeder screw, allowing fluid/air to go into jar. When the flow stops, close the bleeder screw, and have the assistant release the pedal. Repeat this procedure until the fluid is clear and free of air bubbles. Move to next wheel in sequence, and repeat the procedure until all wheels have been bled and brake pedal is firm—not spongy any longer. Discard used brake fluid in accordance with local regulations. ***Never*** reuse brake fluid. Make sure to fill master cylinder periodically (every 3–4 bleeds). Do ***not*** allow it to run out of fluid.
5. Pressure Bleeding	5. Can be performed by one person working alone. Fill bleeder tank to proper level, and pressurize it with shop air to specified air pressure: either psi (usually 10–15 psi) or kPa (usually 69–103 kPa). Fill master cylinder to proper level, and install bleeder adapter in accordance with manufacturer's guidelines. Following manufacturer's instructions, begin bleeding process in correct sequence. **Note:** You may need to open the metering valve assembly before bleeding to get all air from front brakes. Consult the service manual. Again, attach bleeder hose and jar as in manual bleeding. Open pressure bleeder valve on tank. Open brake bleeder screw until fluid is clear and free of air bubbles.

Presentation Outline	Steps to Cover/Key Points to Make
	Repeat procedure until brake pedal is firm. **Key Point:** Do not forget to remove the metering valve hold-open tool prior to driving. Discard used fluid properly.
6. Vacuum Bleeding	6. Can be performed with one person working alone. Fill master cylinder (check every 3–4 bleeds). Follow ***reverse*** of bleeding sequence. Attach vacuum bleeder to bleeder screw, pump vacuum pump to 20"Hg, and open bleeder screw. When vacuum pump gauge reads 0"Hg, close the bleeder. Repeat until all air is removed. Discard used fluid properly.
7. Flushing	7. Hydraulic system must be flushed every year for most anti-lock brake system (ABS) vehicles. Flushing can be done using any of the bleeding methods, but pressure flushing is the best method. Simply bleed each bleeder screw until there is new, fresh, clear fluid coming out. When completed, fill master cylinder to its correct level. Discard used fluid properly.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can work with students on problems involving Pascal's law (P = FA). The applied science teacher can provide lessons on chemical reactions and on vacuums (how a vacuum is create and what effect it has on liquids and air).

Review:

Ask students review questions such as the following:

1. True or False? Using old brake fluid over again is a standard procedure in the automobile service profession.
2. Describe in detail how to manually bleed a brake system.

Application:

1. Have each student list or diagram the correct bleeding sequence for a minimum of five different vehicles (each produced by a different manufacturer).
2. Hold a clinic for other classes to give students a chance to practice bleeding techniques.

Evaluation:

√ Each student will bleed, flush, and pressure-test a brake hydraulic system and determine needed repairs. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.3.4/3.3.5.

Competency 3.3.4: Bleed (manual, pressure, vacuum, or surge) and/or flush hydraulic brake system in accordance with manufacturer's specifications

Competency 3.3.5: Pressure-test brake hydraulic system; determine needed repairs

Performance Checklist

In bleeding, flushing, and pressure-testing a brake hydraulic system and determining needed repairs, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
3. Selected correct tool(s) to use	☐	☐	☐	☐	☐
4. Protected painted surfaces	☐	☐	☐	☐	☐
5. Selected appropriate bleeding method	☐	☐	☐	☐	☐
6. Flushed/bled hydraulic system in accordance with standard procedure and manufacturer's specifications	☐	☐	☐	☐	☐
7. Repeated procedure until fluid was clear and free of bubbles and brake pedal was firm	☐	☐	☐	☐	☐
8. Ensured that master cylinder did not run out of fluid	☐	☐	☐	☐	☐
9. Discarded used brake fluid in accordance with local regulations	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 3: Mechanical and Electrical Components

Subunit 3.3: Brakes

Competency 3.3.8: Remove and reinstall caliper assembly

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Remove and reinstall a caliper assembly
Criteria:	In accordance with the criteria in the checklist for Competency 3.3.8

Introduction:

General Introductory Techniques: Share personal experiences you have had when removing and reinstalling caliper assemblies in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. A caliper is a C-shaped housing that fits over the rotor, containing the pads and the hydraulic components that force the pads against the rotor during braking.

2. Show diagrams of calipers and components.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Place vehicle on jack stands. Loosen and remove lug nuts from wheel. **Key Point:** Put lug nuts in a container (e.g., coffee can or box) to prevent their loss. Remove wheel.
3. Removing Caliper	3. Caliper needs to be removed when— • it is to be replaced/rebuilt; • brake pads are installed; • spindle is replaced; or • rotors are replaced or turned. Remove bolts from back of caliper. Slide caliper off of the rotor. Using proper tool, push the piston back into the caliper chamber so caliper is free for removal. At this point, you could carry out any specified repair/replacement.

Presentation Outline	Steps to Cover/Key Points to Make
4. Reinstalling Caliper	4. **Key Point:** The piston must be completely compressed in the caliper chamber so there is space to install caliper over the rotor. Place caliper over the rotor. Clean bolt threads and then lubricate them. Reinstall bolts in back of caliper. **Critical Safety Step:** Get in the car and pump the brakes to activate the caliper piston. Check brake fluid level in master cylinder, and fill if needed. **Key Point:** Be sure brake fluid does not come into contact with paint; it eats paint.
5. Reinstalling Wheel	5. Replace wheel and lug nuts. Torque lug nuts in accordance with manufacturer's specifications (3.1.54/ 3.3.7).
6. Lowering Vehicle Off Jack Stands	6. Remove jack stands. Lower vehicle, after ensuring that there are no objects in the way.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on torque, friction, force (brake fluid on piston), and how hydraulic pressure is created in a braking system.

Review:

Ask students review questions such as the following:

1. What is the purpose of the caliper?
2. What is the most critical safety factor when you are reinstalling a caliper?
3. In what situations would a caliper need to be removed?

Application:

1. Show students a caliper with a frozen piston, and ask to them explain what would happen if the vehicle was driven.
2. As students practice removing and reinstalling a caliper assembly, quiz them individually on the process (e.g., ask them to identify the components: spindle, rotor, caliper, pad, piston).

Evaluation:

√ The student will remove and reinstall a caliper assembly. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.3.8.

Competency 3.3.8: Remove and reinstall caliper assembly

Performance Checklist

In removing and reinstalling a caliper assembly, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Placed vehicle securely on jack stands	☐	☐	☐	☐	☐
4. Removed wheel	☐	☐	☐	☐	☐
5. Placed lug nuts in secure location	☐	☐	☐	☐	☐
6. Removed bolts from caliper	☐	☐	☐	☐	☐
7. Slid caliper off rotor	☐	☐	☐	☐	☐
8. Pushed piston into caliper chamber	☐	☐	☐	☐	☐
9. Cleaned and lubricated bolts	☐	☐	☐	☐	☐
10. Reinstalled caliper	☐	☐	☐	☐	☐
11. Pumped brakes to ensure piston was back in position	☐	☐	☐	☐	☐
12. Checked brake fluid and added fluid if needed	☐	☐	☐	☐	☐
13. Reinstalled wheel and torqued to manufacturer's specifications	☐	☐	☐	☐	☐
14. Lowered vehicle off jack stands according to standard procedure	☐	☐	☐	☐	☐
15. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 3.3.10: Check parking brake system operation

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid and manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check parking brake system operation
Criteria:	In accordance with the criteria in the checklist for Competency 3.3.10

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking parking brake system operation in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. It is critical that a vehicle's parking brake be in proper working order, because it may be the only thing holding the vehicle still when it is parked.
2. Explain how, in general, the parking brake operates.
3. Discuss whether parking brake should be applied on vehicles with automatic transmissions.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Inspecting Parking Brake	2. Apply parking brake. As a rule of thumb, the pedal or lever should not move more than about 65% (2/3) of full travel and hold the vehicle still in neutral. Inspect cables and linkage for problems such as the following: • Rust • Frozen parts • Fraying • Disconnected components Inspect pedal or lever mechanisms for damage. Make sure you lubricate all necessary points in the system with the recommended lubricant.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons in the application of mechanical force through gears, pulleys, cables, and levers.

Review:

Ask students review questions such as the following:

1. Why is it important to keep the proper lubrication on parking brake cables? (List as many reasons as you can.)
2. How should you test the parking brake's operation?

Application:

1. Give students a teacher-prepared diagram of a parking brake, and have them label the components.
2. Have students locate and outline the procedure for checking parking brakes for two vehicles of different makes.

Evaluation:

√ Each student will check parking brake system operation. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.3.10.

Competency 3.3.10: Check parking brake system operation

Performance Checklist

In checking parking brake system operation, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
4. Checked amount of travel in pedal or lever	☐	☐	☐	☐	☐
5. Inspected cables and linkage for damage	☐	☐	☐	☐	☐
6. Inspected pedal or lever mechanisms for damage	☐	☐	☐	☐	☐
7. Lubricated all necessary points using recommended lubricant	☐	☐	☐	☐	☐
8. Performed final visual inspection	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.9: Restraint Systems: Passive Restraint Systems

Competency 3.9.1:	Inspect, remove, and replace seatbelt and shoulder harness assembly and components in accordance with manufacturer's procedures

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, remove, and replace seatbelt and shoulder harness assembly and components
Criteria:	In accordance with the criteria in the checklist for Competency 3.9.1

Introduction:

General Introductory Techniques: Share personal experiences you have had when inspecting, removing, and replacing seatbelt and shoulder harness assemblies and components in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students if anyone knows or can guess when seat belts were first introduced.
2. Ask students to give reasons why seat belts are so important.
3. Show students examples of damaged seat belts.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Inspecting the Seat Belt	2. Look for the following conditions: • Cuts • Fraying • Pulled threads • Slow retraction **Key Point:** Never repair a seat belt! Seat belts should always be replaced.
3. Removing Seat Belt Restraint System	3. Remove trim to get access to mounting bolts. Unplug any electrical connections. Remove mounting bolts using appropriate tools. **Key Point:** Use caution when removing bolts. They can easily be stripped. Remove seat belt from vehicle once loosened.

Presentation Outline	Steps to Cover/Key Points to Make
4. Inspecting Mounting Area	4. Look for the following conditions: - Rust - Damage due to collision - Stripped threads Repair and replace as necessary and in accordance with manufacturer's specifications. **Note:** Areas of rust ***must*** be repaired. **Key Point:** Always use new hardware if included with new part.
5. Attaching Seat Belts	5. Recommended seat belt installation order: - Align retractor assembly, and start bolt by hand. - Align harness assembly, and start bolt by hand. - Torque bolts in retractor harness in accordance with manufacturer's specifications. - Reattach any electrical connectors, and check operation. - Reattach trim. **Key Point:** When attaching seat belts, be sure to verify smooth operation and check for foreign objects in the track.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover torque specifications for fasteners. The applied science teacher could provide lessons on force and gravitational pull (G's) in collisions.

Review:

Ask students review questions such as the following:

1. What is the proper sequence for installing a seat belt?
2. For what reason(s) should a seat belt be replaced?
3. Can a seat belt be repaired? Why or why not?

Application:

1. Provide students with a variety of seat belts, and ask them to determine whether each one needs to be replaced and to justify their decisions.

2. As students practice removing and replacing seat belts, quiz them individually on the process (e.g., ask them to outline the replacement sequence).

Evaluation:

√ The student will inspect, remove, and replace seatbelt and shoulder harness assembly and components. His/her performance will be evaluated using a copy of the performance checklist for Competency 3.9.1.

Competency 3.9.1: Inspect, remove, and replace seatbelt and shoulder harness assembly and components in accordance with manufacturer's procedures

Performance Checklist

In inspecting, removing, and replacing seatbelt and shoulder harness assembly and components, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Removed trim without damaging it	☐	☐	☐	☐	☐
4. Unplugged any electrical connections	☐	☐	☐	☐	☐
5. Removed seatbelt components in correct order	☐	☐	☐	☐	☐
6. Ensured bolts were removed carefully, without stripping	☐	☐	☐	☐	☐
7. Identified any rust or damage	☐	☐	☐	☐	☐
8. Repaired/replaced rust or damage in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
9. Replaced seatbelt components in proper sequence and in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
10. Torqued bolts to manufacturer's specifications	☐	☐	☐	☐	☐
11. Reattached electrical connectors and checked operation	☐	☐	☐	☐	☐
12. Reattached trim	☐	☐	☐	☐	☐
13. Verified smooth operation of seatbelt	☐	☐	☐	☐	☐
14. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 3: Mechanical and Electrical Components

Subunit 3.10: Restraint Systems: Supplemental Restraint Systems (SRS)

Competency 3.10.1: Disarm SRS in accordance with manufacturer's procedures
Competency 3.10.4: Verify that SRS is operational in accordance with manufacturer's procedures

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Disarm SRS and verify that system is operational

Criteria: In accordance with the criteria in the checklist for Competencies 3.10.1/ 3.10.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when disarming an SRS and verifying that the system is operational. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain that supplemental restraint systems (SRSs) are commonly called air bag systems.
2. Ask students for their opinions about airbags: benefits? problems?
3. Ask how many students have vehicles with airbags.
4. Explain that airbags were patented in the '50s, produced initially (first real one) in 1973, and made mandatory in 1995.
5. Show students a deployed air bag.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. Critical to wear proper safety equipment: • Powder residue left after deployment may contain small amounts of sodium hydroxide. • May irritate skin, eyes, nose, and throat.
3. Disarming SRS	3. Steps should be performed in the following order: • Turn ignition off. • Disconnect battery cable (3.2.6). • Wait amount of time specified by manufacturer (some have a back-up power source of up to 30 minutes). • Disconnect wire connectors to each air bag (driver's and passenger's) in accordance with manufacturer's specifications.
4. Removing Air Bags	4. Remove mounting bolts, being careful not to damage wire connectors; and remove air bag from mounting surface. **Key Point:** Deployment of the passenger's air bag generally requires the dash to be replaced.

Presentation Outline	Steps to Cover/Key Points to Make
5. Removing Steering Wheel	5. Remove steering wheel nut. Remove steering wheel. (This may require a steering wheel puller.) Inspect steering wheel for damage caused by deployment. **Key Point:** Some manufacturers require the steering wheel to be replaced after deployment.
6. Removing the Clock Spring (Coil or Cable Reel)	6. Clock spring allows electrical signal to travel through the steering wheel to the air bag. General removal procedure: • Remove screws. • Unplug connectors. • Remove clock spring.
7. Identifying and Correcting Damage	7. Inspect for damage: • Check steering column to see if it has been collapsed. • Check horn and other steering wheel–mounted accessories. Replace damaged parts. **Key Point:** Do not reuse old fasteners. Use the fasteners that come with the new parts. Torque fasteners in accordance with manufacturer's specifications.
8. Activating System	8. All inspections should have been completed and necessary parts replaced before activating system. Remove objects from in front of the air bag. Areas in front of area must be clear. Connect battery cables (3.2.6). **Key Point:** Do not sit or stand in front of air bag; accidental deployment is possible.

Presentation Outline	Steps to Cover/Key Points to Make
9. Verifying System Operation	9. The only 100% sure test for an air bag system is to crash-test and deploy the air bag. However, the procedure used by technicians to determine whether the air bag system is working properly is the system operation check or *SIR* diagnostic check: • Turn ignition on. **Key Point:** When ignition is turned on, the diagnostic module (SIR) performs a self-test of systems' parts and wiring. • Observe operation of air bag warning light on dashboard. **Note:** Operation lights may vary depending on manufacturer. • When the air bag warning light comes on, the system is doing a self-test. If the light goes out, this indicates that the diagnostic module has discovered no problems in the system and repairs are complete. When the light stays on or flashes after the self-test, this indicates that the diagnostic module has detected a problem. • Correct the problem in accordance with manufacturer's specifications. **Key Point:** When the dash light stays on or flashes indicating there are problems in the system, this does ***not*** mean the system is disabled. The possibility of accidental deployment may ***increase*** because the light is on. Disarm SRS (Step 2) before making any additional repairs. • Recheck system to verify operation.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide information on how the air bag works: electrical signal from control module ignites an ignitor, and as it burns, it causes the release of argon gas, which inflates the air bag.

Review:

Ask students review questions such as the following:

1. What is the purpose of the clock spring?
2. What steps should be followed when disarming an air bag system?
3. What are the steps in activating an air bag system?
4. What is the purpose of the dash light?

Application:

1. If possible, demonstrate air bag deployment for students.
2. Give students a teacher-prepared diagram of an air bag system, and ask them to label the components.
3. Provide students with a damaged air bag system, and ask them to diagnose the problem(s).

Evaluation:

√ The student will disarm an SRS and verify that the system is operational. His/her performance will be evaluated using a copy of the performance checklist for Competencies 3.10.1/3.10.4.

Competency 3.10.1: Disarm SRS in accordance with manufacturer's procedures
Competency 3.10.4: Verify that SRS is operational in accordance with manufacturer's procedures

Performance Checklist

In disarming an SRS and verifying that the system is operational, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Disarmed the air bag system in accordance with established procedure (correct steps performed in correct order)	☐	☐	☐	☐	☐
4. Removed air bag mounting bolts without damaging wire connectors	☐	☐	☐	☐	☐
5. Removed each of the following in accordance with established procedure:					
a. Air bag	☐	☐	☐	☐	☐
b. Steering wheel	☐	☐	☐	☐	☐
c. Clock spring	☐	☐	☐	☐	☐
6. Identified all damage (e.g., to steering wheel, steering column, steering wheel–mounted accessories)	☐	☐	☐	☐	☐
7. Replaced damaged components in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
8. Ensured that no old fasteners were reused	☐	☐	☐	☐	☐
9. Activated system with concern for safety	☐	☐	☐	☐	☐
10. Verified system operation using appropriate procedure	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 4.1.1:	Identify the types of plastics to be repaired
Competency 4.1.2:	Identify the types of plastics repair procedures; clean and prepare the surface of plastic parts in accordance with manufacturer's procedures/industry guidelines
Competency 4.1.9:	Prepare repaired areas for refinishing

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Identify type of plastic and repair procedure, clean and prepare surface, repair thermoplastics, and prepare repaired area for refinishing
Criteria:	In accordance with the criteria in the checklist for Competencies 4.1.1/4.1.2/4.1.9

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when identifying types of plastic and repair procedures, cleaning and preparing plastic surfaces, repairing thermoplastics, and preparing repaired areas for refinishing. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students to list the parts of the vehicle that can be made from plastic.

2. Show students various plastic pieces.

3. Ask students why they think manufacturers have changed to using plastic rather than steel.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. Read and understand all warning labels. Always control dust when cutting, sanding, or grinding plastics. Wear rubber gloves when working with resins and hardeners. Use protective skin cream on any exposed areas of the body. Wash skin thoroughly with Borax soap or alcohol if it comes in contact with resin or hardeners. Always wear safety glasses. Always work in a well-ventilated area. Wear a respirator to avoid inhaling dust and resin vapors.
3. Types of Plastics Used in Automotive Construction	3. Thermoplastics • Can be softened and reshaped with heat • Can be welded with a plastic welder Thermoset • Undergo a chemical change when heated • Are not weldable but can be repaired with a flexible parts repair material

Presentation Outline	Steps to Cover/Key Points to Make
4. Identifying Unknown Plastics	4. Identification methods: • Check international symbols or ISO codes that are molded into the back side of the part. • Use a flame to burn a small piece of plastic while observing the color and odor of the smoke (called the *burn test*). **Key Point:** The burn test is not environmentally sound and is not always reliable because many parts are made from composite plastics (i.e., plastics containing more than one substance). • Use trial-and-error weld. Make trial welds using a plastic welder. Once you have found a filler rod that is compatible, you can identify the plastic.
5. Repairing Thermoplastics	5. Clean entire panel with soap and water. Dry thoroughly. Clean the part with a plastic cleaner. **Key Point:** Do not use a conventional wax and grease remover because this can cause adhesion failure. V-groove the damaged area with 80-grit sandpaper on a DA sander. If damaged area is ripped or torn, weld it using correct filler rod and in accordance with manufacturer's specifications. Allow weld to air-cool for about 20 minutes, then sand with 80-grit sandpaper to proper shape. Apply an approved flexible filler, and sand with 180-grit sandpaper to achieve proper shape and contour. **Key Point:** Several coats may be required. Be sure to follow proper curing times as specified by manufacturer.

Presentation Outline	Steps to Cover/Key Points to Make
6. Preparing Repaired Areas for Refinishing	6. Sand repaired area with 240-grit sandpaper. Mask area. Prime area with a flexible type of primer. Repair is now ready for refinishing.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can work with students on using the burn test to identify different plastics and its environmental effects and using different temperatures to change the shape of plastic.

Review:

Ask students review questions such as the following:

1. What two types of plastic are used in automotive construction?
2. What are three ways to identify an unknown plastic?
3. What procedure should be followed in repairing plastic parts once they have been identified?

Application:

1. As students practice repairing thermoplastic parts, quiz them individually on the process (e.g., ask them to demonstrate the safe use of the plastic welder).
2. Give students samples of different types of plastic, and have them identify each plastic using ISO symbols and/or burn test.

Evaluation:

√ The student will identify type of plastic and repair procedure, clean and prepare surface, repair thermoplastics, and prepare repaired area for refinishing. His/her performance will be evaluated using a copy of the performance checklist for Competencies 4.1.1/4.1.2/4.1.9.

Competency 4.1.1: Identify the types of plastics to be repaired
Competency 4.1.2: Identify the types of plastics repair procedures; clean and prepare the surface of plastic parts in accordance with manufacturer's procedures/industry guidelines
Competency 4.1.9: Prepare repaired areas for refinishing

Performance Checklist

In identifying type of plastic and repair procedure, cleaning and preparing surface, repairing thermoplastics, and preparing repaired area for refinishing, the student—

	1	**2**	**3**	**4**	**5**
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly identified type of plastic	☐	☐	☐	☐	☐
4. Determined type of repair needed	☐	☐	☐	☐	☐
5. Cleaned and prepped area for welding	☐	☐	☐	☐	☐
6. Selected appropriate filler rod and weld repair	☐	☐	☐	☐	☐
7. Used approved filler material and curing times	☐	☐	☐	☐	☐
8. Shaped to correct contour	☐	☐	☐	☐	☐
9. Sanded area using correct sandpaper grit(s)	☐	☐	☐	☐	☐
10. Primed repair area using flexible primer	☐	☐	☐	☐	☐
11. Prepared area so it was ready for refinishing	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 4.1.4:	Repair plastic parts with urethane or epoxy adhesives; use reinforcements if necessary
Competency 4.1.5:	Repair holes and cuts in rigid and flexible plastic parts using backing materials and adhesives
Competency 4.1.9:	Prepare repaired areas for refinishing

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Repair holes, cuts, gouges, etc., in thermoset plastic parts; and prepare repaired area for refinishing
Criteria:	In accordance with the criteria in the checklist for Competencies 4.1.4/4.1.5/4.1.9

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when repairing holes, cuts, gouges, etc., in thermoset plastic parts and preparing repaired areas for refinishing. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students to list the parts of the vehicle that can be made from plastic.
2. Ask students to describe the characteristics of sheet-molded compound (SMC) or thermoset plastics.
3. Show students various plastic pieces.
4. Discuss the differences in sandpaper grits.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. Read and understand all warning labels. Always control dust when cutting, sanding, or grinding plastics. Wear rubber gloves when working with resins and hardeners. Use protective skin cream on any exposed areas of the body. Wash skin thoroughly with Borax soap or alcohol if it comes in contact with resin or hardeners. Always wear safety glasses. Always work in a well-ventilated area. Wear a respirator to avoid inhaling dust and resin vapors.
3. Cleaning Repair Area on Thermosetting Plastics	3. Clean entire panel with soap and water. Dry thoroughly. Clean repair area with a plastic cleaner. **Key Point:** Do not use a conventional wax and grease removers because this can cause adhesion problems.

Presentation Outline	Steps to Cover/Key Points to Make
4. Preparing Back Plate	4. Remove paint by grinding front and back sides of repair area with 36-grit sandpaper. Using same type of plastic, cut out a piece that will overlap repair by at least 50mm to be used as a backing plate. Test-fit backing plate on the back side of repair area. Trim off rough edges of repair as necessary to make a clean fit.
5. Applying Structural Adhesive	5. Structural adhesives can bond plastic to metal and also act as a seal to keep out water, fumes, dust, and wind noise. Once backing plate is properly fitted, apply an approved urethane or epoxy adhesive to the backing plate. Secure backing plate into position. Follow manufacturer's specifications for curing times and temperatures. **Key Point:** Improper curing may cause product shrinkage. An auxiliary heat source (e.g., heat lamp with infrared heat) may be required in curing many products.
6. Shaping and Feathering	6. Use 80-grit sandpaper on a DA sander to feather out scratches from 36-grit sandpaper and to shape epoxy adhesive to proper contour.
7. Filling Holes and Gouges	7. Mix two-part flexible repair material. Apply to repair area. **Key Point:** Do not use ordinary body fillers. These products are not compatible with most thermosetting plastics. Shape repair material with 80-grit sandpaper. **Note:** Additional coats may be required. After sanding to correct shape and contour, a polyester filler can be used to fill any heavy scratches and pinholes. Sand with 180-grit sandpaper.

Presentation Outline	Steps to Cover/Key Points to Make
8. Preparing Surface for Painting	8. Sand entire repair area with a DA sander and 240-grit sandpaper. Mask area for primer. Spray on adhesion promoter. Mix primer with recommended flex-additive. Repair is now ready for refinishing.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can work with students on mixing two or more components (interactions of chemicals) and using infrared heat to cure adhesives. The applied mathematics teacher can work on ratios related to mixing solutions.

Review:

Ask students review questions such as the following:

1. What grit of sandpaper should be used to remove paint prior to repair?
2. How big should the backing plate be?
3. What could happen if proper curing times are not followed?

Application:

1. Provide students with a variety of scrap plastics, and have them use different products on each plastic and document the results.
2. As students practice repairing holes, cuts, gouges, etc., in different plastic parts, quiz them individually on the process (e.g., ask them to demonstrate the safe use of the plastic welder).

Evaluation:

√ The student will repair holes, cuts, gouges, etc., in thermoset plastic parts and prepare repaired area for refinishing. His/her performance will be evaluated using a copy of the performance checklist for Competencies 4.1.4/4.1.5/4.1.9.

Competency 4.1.4: Repair plastic parts with urethane or epoxy adhesives; use reinforcements if necessary
Competency 4.1.5: Repair holes and cuts in rigid and flexible plastic parts using backing materials and adhesives
Competency 4.1.9: Prepare repaired areas for refinishing

Performance Checklist

In repairing holes, cuts, gouges, etc., in thermoset plastic parts and preparing repaired area for refinishing, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) and sandpaper grits to use	☐	☐	☐	☐	☐
3. Thoroughly cleaned and dried repair area	☐	☐	☐	☐	☐
4. Removed paint on both sides of repair area using 36-grit sandpaper	☐	☐	☐	☐	☐
5. Prepared backing plate of correct material and size	☐	☐	☐	☐	☐
6. Mixed, applied, and cured adhesive in accordance with product manufacturer's specifications	☐	☐	☐	☐	☐
7. Secured backing plate into position	☐	☐	☐	☐	☐
8. Feathered out scratches and properly shaped adhesive using 80-grit sandpaper	☐	☐	☐	☐	☐
9. Mixed and applied polyester filler in accordance with product manufacturer's specifications	☐	☐	☐	☐	☐
10. Shaped repair to proper contour	☐	☐	☐	☐	☐
11. Sanded area using correct sandpaper grit(s)	☐	☐	☐	☐	☐
12. Mixed primer in accordance with product manufacturer's specifications	☐	☐	☐	☐	☐
13. Prepared area so it was ready for refinishing	☐	☐	☐	☐	☐
14. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 5: Painting and Refinishing
Subunit 5.1: Safety Precautions

Unit 6: Basic Shop and Safety Practices

Competency 5.1.1:	Identify and take necessary precautions with hazardous operations and materials according to federal, state, and local regulations
Competency 5.1.2:	Identify personal health and safety hazards according to OSHA guidelines and "Right to Know" Act
Competency 6.4:	Maintain safe work environment

Competency Development Guide

Objective:

Condition:	As part of all activities in the collision repair facility
Behavior:	Maintain a safe work environment
Criteria:	In accordance with the criteria in the checklist for Competencies 5.1.1/5.1.2/6.4

Introduction:

General Introductory Techniques: Share personal experiences you have related to the safety of the work environment. Show videos that demonstrate how to maintain a safe work environment and/or consequences of an unsafe environment.

Competency-Specific Information:

1. 1994 OSHA Standard (29 CFR 1910, 1200) covers material safety data sheets (MSDSs) and employee's right to know.

2. Having a well-organized, clean, well-maintained, and well-lit shop is one good way to maintain a safe work environment.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Shop Cleanliness	1. Importance of maintaining clean work environment How to clean shop
2. Air Filtering and Ventilation	2. General guidelines: • An exhaust fan that will promote air circulation is required by some states. • Dust collectors should be used daily to remove dust and air-borne particles; clean and change filters per manufacturer's recommendations. • Paint booth filters should be changed per manufacturer's recommendations.
3. Air Pressure Regulation	3. There are regulators throughout shop where air lines come in. The pressure of the air in those lines is 175 psi. Most *pneumatic* (air-powered) equipment uses 30–120 psi (e.g., sanders, drills, grinders, spray guns). Manufacturer's specifications will identify the appropriate psi range for each piece of equipment. To regulate the pressure, you turn the knob provided until the needle gauge shows the recommended range. When the psi range is correct, the equipment operates most efficiently. If the psi is too high, it can damage the equipment and produce a noise level higher than OSHA safety standards allow.

Presentation Outline	Steps to Cover/Key Points to Make
4. Sources of Contamination and Other Hazards (Identification/Containment)	4. Acute contamination Chronic contamination Air-borne contamination Other hazards (e.g., asbestos) Shop rags used to clean parts
5. Draining, Removal, and Storage of Gasoline Tanks	5. Established safety procedures (check with local fire department) Why a nearly empty tank may be more dangerous than a full one
6. Handling of Flammable Liquids	6. Established safety rules (6.2)
7. Labeling of Containers	7. Most often-used products are purchased in large containers (e.g., 5 gallons, 15 gallons, 55 gallons). The containers must be stored away from the main building, and OSHA specifies how much of the product can be brought into the facility at one time (e.g., 5 gallons). For safety, the new (smaller) container must be fireproof (usually color-coded) and clearly labeled. Labeling ensures that users and fire officials can tell exactly what the container holds. It protects humans from danger and vehicles from damage.
8. Storage, Use, Recycling, and Disposal of Hazardous Materials	8. Follow EPA regulations. Check with local fire department, which may have additional regulations. Analyze liability associated with hazardous material disposal. Responsibility does not end when the hazardous material leaves the site.

Presentation Outline	Steps to Cover/Key Points to Make
9. Hazardous Chemical Spills	9. Ohio ranks third in chemical accidents in the nation. Procedure for responding to hazardous chemical spills, including— • Keep material away from the drains. • If unsure, stay away. • Report per EPA guidelines. • Report to fire department if necessary.
10. Unsafe Practices and Conditions	10. Report unsafe practices and conditions. The instructor needs the eyes, ears, and noses of everyone in the shop. Correct unsafe practices and conditions. Don't leave spilled products on the floor. Person responsible for spill should clean it.
11. OSHA Right-to-Know Laws	11. Consumers have a right to information about— • product ingredients, when those ingredients are not a trade secret; and • any hazards, whether they are a trade secret or not. Hazard Communication Standard
12. Material Safety Data Sheets (MSDSs)	12. MSDSs identify the following: • Possible hazards when using the materials • Protective measures to take when using the materials • What to do if exposed to a material

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on documenting storage of hazardous materials and reading and interpreting MSDSs. The applied science teacher could discuss environmental and physical safety concerns associated with working with hazardous materials.

Review:

Ask students review questions such as the following:

1. What is the pressure of the air coming into the shop through the air station outlets, and how do you determine what psi setting to use for a particular piece of equipment?
2. What is the difference between acute and chronic?
3. Do you have the right to know about hazardous materials if they are a trade secret? Explain your answer.
4. What is the best way to handle an oil spill?
5. When does responsibility end for a hazardous waste?

Application:

1. Give students a sample MSDS, and have them identify the hazards related to the chemical, protective measures to take when using it, and consequences of exposure to the chemical.
2. Give students written case studies describing situations involving different chemical spills, and have them explain how to respond to each in accordance with shop policy.
3. As students practice cleaning up spills, quiz them individually on the process (e.g., ask them how to select the appropriate cleaning supplies to use).

Evaluation:

√ Each student will maintain a safe work environment. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.1.1/5.1.2/6.4.

Competency 5.1.1:	Identify and take necessary precautions with hazardous operations and materials according to federal, state, and local regulations
Competency 5.1.2:	Identify personal health and safety hazards according to OSHA guidelines and "Right to Know" Act
Competency 6.4:	Maintain safe work environment

Performance Checklist

In maintaining a safe work environment, the student—

	1	2	3	4	5
1. Selected correct equipment and supplies to use	☐	☐	☐	☐	☐
2. Followed TSB safety recommendations	☐	☐	☐	☐	☐
3. Maintained clean work environment	☐	☐	☐	☐	☐
4. Followed EPA regulations for air filtering and ventilation of the work environment	☐	☐	☐	☐	☐
5. Regulated air pressure to equipment manufacturer's specifications	☐	☐	☐	☐	☐
6. Identified sources of contamination and other hazards	☐	☐	☐	☐	☐
7. Contained sources of air-borne contamination and other hazards (e.g., asbestos)	☐	☐	☐	☐	☐
8. Followed established safety procedures for the draining, removal, and storage of gasoline tanks	☐	☐	☐	☐	☐
9. Followed safety rules for handling flammable liquids	☐	☐	☐	☐	☐
10. Labeled containers according to OSHA regulations	☐	☐	☐	☐	☐
11. Followed EPA regulations for the storage, use, recycling, and disposal of hazardous materials	☐	☐	☐	☐	☐
12. Analyzed the liability associated with hazardous material disposal	☐	☐	☐	☐	☐
13. Responded to hazardous chemical spills	☐	☐	☐	☐	☐
14. Reported unsafe practices and conditions	☐	☐	☐	☐	☐
15. Corrected unsafe practices and conditions	☐	☐	☐	☐	☐
16. Interpreted OSHA Right-to-Know law	☐	☐	☐	☐	☐
17. Interpreted material safety data sheets (MSDSs)	☐	☐	☐	☐	☐
18. Identified resources for employee's rights to information	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**________ _______

Competency 5.1.3:	Inspect spray environment for cleanliness and safety hazards
Competency 5.3.1:	Inspect, clean, and determine condition of spray guns and related equipment (air hoses, regulators, air lines, air source, and spray environment)

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Inspect, clean, and determine condition of spray guns and related equipment
Criteria:	In accordance with the criteria in the checklist for Competencies 5.1.3/5.3.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when inspecting, cleaning, and determining condition of spray guns and related equipment. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Display (or pass around) two paint guns—one clean and one dirty—for students to examine and compare.

2. Explain importance of proper care and maintenance of spray guns—the costs in time and money that can result from improper care and maintenance (e.g., spitting, poor spray pattern, foreign material in paint).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Inspecting Spray Guns	2. Visually inspect the spray gun for wear, damage, and cleanliness. Check the following: • Fittings (are they loose?) • Air cap • Fluid tip • Fluid needle • Cup gasket (if applicable) • Cup Determine whether parts are okay, need to be cleaned, or should be replaced.
3. Cleaning Spray Guns	3. Cleaning tips: • Follow manufacturer's instructions. • Use appropriate safety equipment when handling solvents. • Use caution when using compressed air to clean a spray gun. • Clean spray gun immediately after each use.

Presentation Outline	Steps to Cover/Key Points to Make
	General guidelines for cleaning: • Empty paint from cup. • Fill cup 1/3 full with solvent. • Spray solvent through spray gun using low air pressure (15–25 lbs). • Remove air cap and clean with solvent. **Key Point:** Use wooden toothpick to clean orifices. Never use metal wire or welding tip cleaner; these can damage the orifices. • Clean fluid nozzle with solvent. • Replace air cap. • Clean gun body with solvent. • Clean cup assembly with solvent. • Replace cup assembly in gun body. • Lubricate per manufacturer's specifications.
4. Inspecting and Cleaning Air Hoses	4. Check for loose or damaged fittings; repair or replace. Check hoses for cracks or splits; replace.
5. Inspecting and Cleaning Regulators	5. Check fittings and gasket, and drain daily.
6. Inspecting and Cleaning Air Lines	6. Make sure the lines are not loose. Check for leaks.
7. Inspecting and Cleaning Air Source (Compressor)	7. Drain supply tank daily. Check condition of drive belts. Change oil per manufacturer's specifications. Change air filter per manufacturer's specifications.

Presentation Outline	Steps to Cover/Key Points to Make
8. Inspecting and Cleaning Spray Environment (Paint Booth)	8. Change filters per manufacturer's specifications. Check door gaskets and seals. Clean and replace lightbulbs as necessary. **Key Point:** Keep booth clean by using it only for its intended purpose: paint spraying. Do all sanding and rubbing outside the booth.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the chemical properties of solvents and why they can be dangerous to humans. The applied communications teacher could help students in locating and interpreting information on how to maintain air compressor, spray booth, etc.

Review:

Ask students review questions such as the following:

1. How often should a spray gun be cleaned?
2. Why is it so important to keep a spray gun clean? Why is it important that the spray gun and related equipment be in optimal working condition?

Application:

1. Provide students with a diagram of a spray gun, and ask students to label the major parts and summarize how each of those parts should be cleaned.
2. Ask students to inspect the spray environment and report on their findings.
3. As students practice inspecting and cleaning a spray gun, quiz them individually on the process (e.g., ask them to show you where they found the manufacturer's recommendations for the procedure to be followed).

Evaluation:

√ The student will inspect, clean, and determine condition of spray guns and related equipment. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.1.3/5.3.1.

Competency 5.1.3:	Inspect spray environment for cleanliness and safety hazards
Competency 5.3.1:	Inspect, clean, and determine condition of spray guns and related equipment (air hoses, regulators, air lines, air source, and spray environment)

Performance Checklist

In inspecting, cleaning, and determining condition of spray guns and related equipment, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Visually inspected each of the following spray gun parts:					
a. Fittings	☐	☐	☐	☐	☐
b. Air cap	☐	☐	☐	☐	☐
c. Fluid tip	☐	☐	☐	☐	☐
d. Fluid needle	☐	☐	☐	☐	☐
e. Cup	☐	☐	☐	☐	☐
f. Cup gasket (if applicable)	☐	☐	☐	☐	☐
4. Identified all wear, damage, and uncleanliness	☐	☐	☐	☐	☐
5. Cleaned spray gun in accordance with standard procedures and manufacturer's guidelines	☐	☐	☐	☐	☐
6. Inspected the following related equipment:					
a. Air hoses	☐	☐	☐	☐	☐
b. Regulators	☐	☐	☐	☐	☐
c. Air lines	☐	☐	☐	☐	☐
d. Air source	☐	☐	☐	☐	☐
e. Spray environment	☐	☐	☐	☐	☐
7. Determined need for cleaning, repairs, or replacements	☐	☐	☐	☐	☐
8. Cleaned related equipment in accordance with standard procedures and manufacturer's guidelines	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing
Subunit 5.1: Safety Precautions

Unit 6: Basic Shop and Safety Practices

Competency 5.1.4:	Select and use the NIOSH-approved personal sanding respirator; inspect condition and ensure fit and operation; perform proper maintenance in accordance with industry/manufacturer's specifications
Competency 5.1.5:	Select and use the NIOSH-approved (Fresh Air Make-up System) personal painting/refinishing respirator system
Competency 5.1.6:	Select and use the proper personal safety equipment for painting/refinishing and sanding (gloves, suits, hoods, eye and ear protection, etc.)
Competency 6.1:	Utilize personal safety equipment

Competency Development Guide

Objective:

Condition:	As part of all activities in the collision repair facility
Behavior:	Utilize personal safety apparel and equipment
Criteria:	In accordance with the criteria in the checklist for Competencies 5.1.4/5.1.5/5.1.6/6.1

Introduction:

General Introductory Techniques: Share personal experiences you have had concerning the use of personal safety apparel and equipment in the collision repair facility. Show videos that show various types of equipment and their use.

Competency-Specific Information:

1. Take an inventory. Have everyone count all their fingers, toes, and any other body parts that they have.

2. Announce that at the end of the year, this inventory will be repeated, and students are expected to come up with the same counts.

3. Explain to students that following all the rules for the use of personal safety equipment will help ensure that nothing will be missing in the end-of-the-year body parts inventory.

References:

OSHA 1920.130 series of Personal Protective Standards. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Eye and Ear Protection	1. Wear eye and ear protection in accordance with Occupational Safety and Health Administration (OSHA) standards. Wearing of safety glasses in vocational labs is also required by Ohio state law. Student's responsibility for securing safety glasses
2. Foot and Hand Protection	2. Wear prescribed foot and hand protection. Wearing leather boots with nonskid soles and steel toes is optional. Protective gloves must be worn for working with solvents and welding.
3. Respiratory Protection	3. Select appropriate type of respirator for operation being performed: • Dust or particle respirator: ~ Do not use for vapors or mist. • Cartridge filter respirator: ~ Use when spraying non-activated, isocyanate-free refinishing materials. ~ Perform a positive and negative pressure test fit. ~ Change filters in accordance with manufacturer's specifications. • Air-supplied respirator (hooded or face mask type): ~ Use for two-component materials or for materials that contain isocyanates. ~ For air-supplied respirators that use an oil-less pump to supply air, change filter in accordance with manufacturer's specifications

Presentation Outline	Steps to Cover/Key Points to Make
	Use and maintain all respiratory protection equipment (respirator, spray mask, and mask filters) in accordance with manufacturer's specifications. Use NIOSH-approved respirators. (NIOSH = National Institute for Occupational Safety and Health) **Key Point:** Facial hair may interfere with fit of particle mask and half-mask respirators.
4. Clothing/Paintsuits	4. Wear clothes that do not interfere with running machinery and in accordance with shop policy. Paintsuits should be worn in accordance with manufacturer's specifications and/or OSHA guidelines. **Key Point:** A paintsuit must be worn when using two-component or isocyanate products.
5. Jewelry	5. Remove jewelry in accordance with shop policy. Remember that a dangling earring or chain can get caught in moving machinery and cause serious injury.
6. Hair	6. Secure long hair (e.g., wear a cap or tie hair back) according to shop policy.
7. Lifting Techniques	7. Bend knees, not back. Get assistance for heavy loads. Use caution when twisting and lifting.
8. Maintaining Personal Protective Equipment	8. Clean protective equipment prior to and after each use. Store protective equipment after each use so that it is not damaged.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can work with students in reading and interpreting OSHA standards. The applied science teacher could cover how to read an MSDS and the effects of different levels of exposure on humans.

Review:

Ask students review questions such as the following:

1. When should safety glasses be worn in the shop?
2. Why is respiratory protection so critical to the safety and long-term health of auto collision technicians?
3. How should you lift heavy objects?
4. List some reasons why jewelry should be removed.
5. Identify three ways long hair could be shortened in a "shop experience."

Application:

1. Have students work in teams to develop safety posters, fliers, handbooks, etc., covering the use of personal safety equipment in the shop.
2. Ask students to perform an instructor- or school-prepared safety inspection of the entire automotive laboratory. (This should be done at ***least*** monthly and at random times.)

Evaluation:

√ Each student will utilize personal safety apparel and equipment. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.1.4/ 5.1.5/5.1.6/ 6.1.

Competency 5.1.4:	Select and use the NIOSH-approved personal sanding respirator; inspect condition and ensure fit and operation; perform proper maintenance in accordance with industry/manufacturer's specifications
Competency 5.1.5:	Select and use the NIOSH-approved (Fresh Air Make-up System) personal painting/refinishing respirator system
Competency 5.1.6:	Select and use the proper personal safety equipment for painting/refinishing and sanding (gloves, suits, hoods, eye and ear protection, etc.)
Competency 6.1:	Utilize personal safety equipment

Performance Checklist

In utilizing personal safety apparel and equipment, the student—

	1	2	3	4	5
1. Selected/used correct equipment	☐	☐	☐	☐	☐
2. Wore eye and ear protection in accordance with OSHA standards	☐	☐	☐	☐	☐
3. Wore prescribed foot and hand protection	☐	☐	☐	☐	☐
4. Wore respiratory protection in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Wore clothing in accordance with OSHA standards and manufacturer's specifications	☐	☐	☐	☐	☐
6. Removed jewelry in accordance with shop policy	☐	☐	☐	☐	☐
7. Secured long hair	☐	☐	☐	☐	☐
8. Practiced established lifting techniques	☐	☐	☐	☐	☐
9. Maintained personal protective equipment	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 5.2.1: Remove, store, and replace exterior trim and molding

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Remove, store, and replace exterior trim and molding
Criteria:	In accordance with the criteria in the checklist for Competency 5.2.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when removing, storing, and replacing exterior trim and molding. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When refinishing a vehicle, it is important to duplicate the factory process as much as possible. This means removing any trim and moldings that may interfere with the refinishing process.

2. Most trim and moldings can be removed. However, some are part of a larger unit and cannot be easily removed (e.g., window glass trim and molding). And some cannot be removed due to physical or economical factors (e.g., if removal of trim and molding would require disassembly of other undamaged components).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Identifying Trim/Molding To Be Removed	2. Check the panels to be refinished and adjacent panels to be blended to identify trim and molding that needs to be removed. Most common items removed: • Door handles and lock cylinders • Side moldings • Mirrors • Reveal moldings • Wheel opening moldings • Head and tail lamp bezels
3. Inspecting Trim/Molding	3. Determine whether each item— • can be removed without damaging it; • can be removed easily—both physically and economically; and • can be reused (check manufacturer's guidelines).
4. Removing and Storing Trim/Molding	4. Remove each item carefully using tools and procedure appropriate for its attachment method. Small parts may be stored in the vehicle Larger items need to be placed in a safe area. Wrap trim/moldings with a protective cover to prevent damage.

Presentation Outline	Steps to Cover/Key Points to Make
5. Replacing Trim/Molding	5. Replace removed trim and molding as necessary, using new clips, screws, self-adhesive, attaching tape, etc., as required.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students in locating and interpreting specifications for trim/molding removal and replacement methods to be used.

Review:

Ask students review questions such as the following:

1. Why is it important to remove trim and moldings from areas to be refinished and blended?
2. How are moldings and trim typically attached to vehicles?
3. Where can you find needed information on molding and trim removal and replacement?

Application:

1. Divide students into small groups, assign each group a list of trim/moldings for a specific vehicle, and have them use appropriate TSBs and manufacturer's repair guides to determine how those trim/moldings are to be removed,
2. As students practice removing, storing, and replacing trim and moldings, quiz them individually on the process (e.g., ask them to point out trim/molding that is not reusable or cannot be removed without damage).

Evaluation:

√ The student will remove, store, and replace exterior trim and molding. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.2.1.

Competency 5.2.1: Remove, store, and replace exterior trim and molding

Performance Checklist

In removing, storing, and replacing exterior trim and molding, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Accurately identified all trim/molding in area to be refinished and blended	☐	☐	☐	☐	☐
4. Determined whether trim/molding could be reused or would need to be replaced	☐	☐	☐	☐	☐
5. Removed trim/molding to be reused without damaging it	☐	☐	☐	☐	☐
6. Stored trim/molding in a safe place	☐	☐	☐	☐	☐
7. Replaced trim/molding as necessary using new fasteners as required	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 5: Painting and Refinishing

Subunit 5.2: Surface Preparation

Competency 5.2.2:	Remove dirt, road grime, and wax or protective coatings from the area to be refinished and adjacent vehicle surfaces; wash entire vehicle
Competency 5.2.3:	Inspect and identify substrate, type of finish, and surface condition; develop a plan for refinishing using a total product system

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Clean vehicle surface; identify substrate, type of finish, and surface condition; and develop a plan for refinishing using a total product system
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.2/5.2.3

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when cleaning vehicle surfaces; identifying substrates, types of finish, and surface condition; and developing plans for refinishing using total product systems. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Before refinishing any vehicle, it is imperative to identify exactly what needs to be refinished, the condition of the part to be refinished, and the materials and procedures necessary to complete the refinishing task. The surface of the vehicle should be cleaned before the inspection process begins.

2. When a properly developed plan is followed, there will be no "surprises" during the refinishing process.

References:

Service manuals; technical service bulletins (TSBs); paint color books and charts; product information manuals from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Removing Dirt, Grease, and Wax	2. Area to be repaired must be cleaned because contaminants left on the surface can cause problems later. For example, grinding and sanding can embed contaminants into sand scratches, which can eventually ruin a new paint job. First, thoroughly wash the area with warm, soapy water. This will remove surface dirt. Then, clean with a wax and grease remover. **Key Point:** When using wax and grease removers, wear vinyl gloves and safety glasses.
3. Identifying Substrate	3. The *substrate* is the material being painted (metal, plastic, old finish, primer, sealer, etc.). To identify the substrate, inspect the material visually to determine which of the following it is: • Metal (steel, aluminum, etc.) • Plastic (sheet-molded compound, fiberglass, urethane, etc.) • Old finish • Primer and/or sealer **Key Point:** To identify specific substrates and refinishing procedures, refer to product manufacturers' guidelines.

Presentation Outline	Steps to Cover/Key Points to Make
4. Determining Whether Vehicle Has Original Finish or Has Been Refinished	4. Three methods most commonly used: • Measure mil thickness using appropriate gauge and compare to manufacturer's specifications (5.5.29). • Sand through all paint layers in an area 1"–2" in diameter using an orbital sander. When base material has been reached, count the layers (or rings) left exposed by the sanding process. **Key Point:** If more than one topcoat is observed, the vehicle has been refinished. • Apply a rag that has been soaked in lacquer thinner to the finish. A lacquer finish will soften readily or quickly. An enamel or urethane finish will show no effect.
5. Identifying Type of Finish	5. Need to identify specific type of finish before refinishing because it is important to duplicate the OEM paint process whenever possible. If original finish— • Refer to refinish guides to determine type of finish (lacquer, enamel, urethane, water-borne, etc.). • Use standard techniques for prepping and refinishing. If the vehicle has been refinished, it will be necessary to determine the type of refinish material in order to ensure compatibility with the products to be used.

Presentation Outline	Steps to Cover/Key Points to Make
6. Determining Surface Condition	6. After the areas have been cleaned with soap and water, followed by a wax and grease remover, examine surface for signs of the following: • Rust • Paint film failure • Checking (cracking in the finish) • Peeling paint • Blistering • Damage from industrial and environmental fallout (e.g., acid rain, rail dust, tree sap, bird droppings)
7. Developing Refinishing Plan	7. **Key Point:** Always use a total product system when refinishing a vehicle: • This ensures that the products being used are all compatible. • Not using a total product system will void any guarantees or warrantees given by the product manufacturer. Identify panel(s) to be refinished and appropriate procedure for refinishing each (e.g., spot, blend, overall). Select undercoats and topcoats to be used. Follow manufacturer's recommendations for the refinish operation(s) and materials needed to complete the painting process.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can assist students in measuring paint thickness (mils). The applied science teacher can cover the history of refinishing materials, paint ingredients (binders, additives, pigments, etc.), and environmental safety and health concerns related to painting and refinishing.

Review:

Ask students review questions such as the following:

1. Why is it important to use a total product system?
2. What three methods are most commonly used in determining whether a vehicle has its original finish?
3. What is a substrate? Give four examples.

Application:

1. Provide students with various vehicles, and ask them to (a) identify each substrate and (b) identify each finish.
2. Provide students with a specific vehicle, and have them work in teams to develop a refinishing plan.

Evaluation:

√ The student will clean vehicle surface; identify substrate, type of finish, and surface condition; and develop a plan for refinishing using a total product system. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.2/5.2.3.

Competency 5.2.2: Remove dirt, road grime, and wax or protective coatings from the area to be refinished and adjacent vehicle surfaces; wash entire vehicle

Competency 5.2.3: Inspect and identify substrate, type of finish, and surface condition; develop a plan for refinishing using a total product system

Performance Checklist

In cleaning vehicle surface; identifying substrate, type of finish, and surface condition; and developing a plan for refinishing using a total product system, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Thoroughly cleaned areas to be refinished and blended	☐	☐	☐	☐	☐
4. Accurately determined—					
a. Type of substrate to be refinished	☐	☐	☐	☐	☐
b. Whether vehicle had original finish or had been refinished	☐	☐	☐	☐	☐
c. Type of finish	☐	☐	☐	☐	☐
d. Surface condition	☐	☐	☐	☐	☐
5. Developed a plan for refinishing vehicle surfaces that specified—					
a. Panel(s) to be refinished	☐	☐	☐	☐	☐
b. Refinishing procedures to be used	☐	☐	☐	☐	☐
c. Undercoats and topcoats to be used	☐	☐	☐	☐	☐
6. Followed manufacturer's recommendations for refinishing operations and materials	☐	☐	☐	☐	☐
7. Used a total product system	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____Date_____________

Unit 5: Painting and Refinishing

Subunit 5.2: Surface Preparation

Competency 5.2.5:	Dry or wet sand areas to be refinished
Competency 5.2.6:	Featheredge broken areas to be refinished
Competency 5.2.12:	Dry or wet sand area to which primer-surfacer has been applied

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Dry- or wet-sand and featheredge areas being refinished
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.5/5.2.6/ 5.2.12

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when dry- or wet-sanding and featheredging areas being refinished. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. The purpose of sanding is to microscopically "rough up" the surface so paint will adhere.

2. Dry-sanding versus wet-sanding:

   - **Dry-sanding** is faster than wet-sanding, and it doesn't get the masking tape or paper wet. Sandpaper clogs more easily with dry-sanding.

   - **Wet-sanding** is slower than dry-sanding. The sandpaper doesn't clog as easily and lasts longer. Water acts as a lubricant, reducing friction. Dust is removed from the surface with the water, but the surface must be dried thoroughly before refinishing. Wet-sanding can cause rust on bare metal areas.

3. Both wet- and dry-sanding can be accomplished by hand or using power equipment.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Selecting Appropriate Sandpaper Grit	2. Select appropriate sandpaper for wet- and dry-sanding. **General Rules of Thumb:** • 180-grit to 240-grit—Fine grade used for final sanding of base metal and for featheredging paint • 240-grit to 400-grit—Fine grade used to sand primer-surfaces and old paint prior to refinishing • 500-grit to 800-grit—Fine grade used to color-sand and prep old finish for refinishing • 1000-grit to 2000-grit—Ultrafine grade used to remove imperfections in finish
3. Featheredging Broken Areas	3. *Featheredging* is the tapering of the damage area or surface. It is always done with dry sandpaper (usually 180-grit to 240-grit). 1/2" to 1" of each layer of product should be visible when properly featheredged.
4. Hand-Sanding	4. Always sand with the line of sight or along the length of the panel. Use a sanding block or a pad whenever possible. Sand until the area is level, and all gloss has been removed.

Presentation Outline	Steps to Cover/Key Points to Make
5. Power-Sanding	5. Two most common power sanders: • DA sander— ~ Used with a dry-type sandpaper ~ Used to featheredge and smooth repair areas ~ Not recommended for use on primer surfaces • Orbital sander (also called a jitterbug)— ~ Used to block primers and other surfaces prior to refinishing ~ Can be used wet or dry

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied math teacher could cover the grading of sandpaper. The applied science teacher could provide lessons on types of abrasives and principles of friction.

Review:

Ask students review questions such as the following:

1. Why is sanding important?
2. What are the advantages and disadvantages of dry-sanding? wet-sanding?
3. What is the purpose of featheredging?

Application:

1. Provide students with a variety of sandpapers, and ask them to identify the abrasive type of each one and explain what that grade of sandpaper should be used for.
2. As students practice prepping a panel for refinishing, quiz them individually on the process (e.g., ask them to explain the procedure they used to select sandpaper and the procedure to follow: wet or dry, hand or power).

Evaluation:

√ The student will dry- or wet-sand and featheredge areas being refinished. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.5/5.2.6/5.2.12.

Competency 5.2.5: Dry or wet sand areas to be refinished
Competency 5.2.6: Featheredge broken areas to be refinished
Competency 5.2.12: Dry or wet sand area to which primer-surfacer has been applied

Performance Checklist

In dry- or wet-sanding and featheredging areas being refinished, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Selected appropriate sandpaper grade/grit	☐	☐	☐	☐	☐
4. Featheredged the broken areas to be refinished in accordance with established procedure	☐	☐	☐	☐	☐
5. Selected appropriate sanding method (dry- or wet-sanding by hand or using power equipment)	☐	☐	☐	☐	☐
6. Applied sanding method in accordance with established procedure	☐	☐	☐	☐	☐
7. Sanded area until level and without gloss	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.2: Surface Preparation

Competency 5.2.7:	Apply suitable metal treatment or primer
Competency 5.2.8:	Mask trim and protect other areas that will not be refinished
Competency 5.2.10:	Spray primer onto surface of repaired area

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Apply metal treatment or primer, protect trim and adjacent areas, and apply primer to repair area
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.7/5.2.8/ 5.2.10

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when applying metal treatment or primer, protecting trim and adjacent areas, and applying primer to repair area. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. There is no substitute for the proper preparation for any repair operation. It's very much like building a house—if the foundation is faulty, you have a recipe for disaster.

2. To provide a solid foundation for painting/refinishing a vehicle, bare metal must be either treated or primed using a high-quality product.

3. Likewise, high-quality masking tape and paper/plastic sheeting designed for the automotive industry must be used to protect areas surrounding the refinish area. Using newspaper and cheap tape is unacceptable. They will allow the solvents to bleed through and damage otherwise undamaged surfaces.

References:

Service manuals; technical service bulletins (TSBs); paint color books and charts; product information manuals from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Applying Metal Treatment	2. Characteristics of metal treatment (also called metal conditioner): • Removes microscopic corrosion • Often requires a conversion coating **Key Point:** The conversion coating can cause metal to change color (usually a blue or whitish hue). This is normal! **Caution:** Metal conditioners and conversion coatings are caustic. Therefore, rubber gloves, eye protection, and protective clothing must be worn when working with these products. General application procedure: • Wipe or spray on metal treatment. • Allow appropriate drying time. • Wipe or spray on conversion coating. Check manufacturer's specifications for specific application procedures. **Key Point:** A self-etching primer—a sprayable product that eliminates the need for a metal conditioner and conversion coating—may be used instead.

Presentation Outline	Steps to Cover/Key Points to Make
3. Protecting Trim and Adjacent Areas	3. If possible, remove trim. If trim cannot be removed, select appropriate masking tape and paper for area to be masked. • Masking tape comes in sizes ranging from 1/16"–2". • Paper comes in sizes ranging from 3"–36". **General Rule of Thumb:** Use the widest possible tape and paper in order to reduce masking time. Apply tape to dry surface, with temperature at least 60°F, or the tape will not adhere. In applying the tape, never stretch it. Allow it to follow contours naturally. Fold pleats in paper, and tape them down to prevent dust or dirt from getting trapped in the pleats. Alternative protection materials: • Plastic sheeting can be substituted for masking paper, but it must be at least 3 mils thick to prevent bleed-through. • Liquid masking material can be sprayed on panels and in fender wells, wheel openings, and jamb areas, but it cannot be used on panels directly adjacent to repair area. Be sure to follow manufacturer's recommendations for the use of all masking products/materials.
4. Selecting Primer for Repair Area	4. Select the appropriate primer for the type of repair: • Self-etching for bare metal • Primer-surfacer for use over body filler or areas requiring the filling properties of a primer-surfacer **Key Point:** To select appropriate primer (e.g., epoxy, primer-surfacer, self-etching), refer to product manufacturer's recommendations.

Presentation Outline	Steps to Cover/Key Points to Make
5. Applying Primer to Repair Area	5. Mix and apply primer in accordance with product manufacturer's recommendations. Be sure to use the appropriate personal protective equipment and apparel.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the chemical properties of caustic products such as conversion coatings and dangers associated with them; properties of masking materials that allow or prevent bleed-through; and why tape will not adhere to wet surface or one less than 60° F.

Review:

Ask students review questions such as the following:

1. Why should a metal conditioner be used on bare metal?
2. What is a conversion coating, and what does it do?
3. Why shouldn't newspaper and cheap masking tape be used to mask a vehicle? What could be the results?

Application:

1. As students practice masking vehicles using masking paper, tape, and plastic, quiz them individually on the process (e.g., ask them to explain the process they followed in deciding whether to remove or mask specific trim).
2. Provide students with a variety of vehicles/panels to examine, and ask them to select the appropriate primer(s) for each.

Evaluation:

√ The student will apply metal treatment or primer, protect trim and adjacent areas, and apply primer to repair area. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.7/5.2.8/5.2.10.

Competency 5.2.7: Apply suitable metal treatment or primer
Competency 5.2.8: Mask trim and protect other areas that will not be refinished
Competency 5.2.10: Spray primer onto surface of repaired area

Performance Checklist

In applying metal treatment or primer, protecting trim and adjacent areas, and applying primer to repair area, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Wiped or sprayed on metal treatment or primer	☐	☐	☐	☐	☐
4. Allowed appropriate drying time	☐	☐	☐	☐	☐
5. Wiped or sprayed on conversion coating	☐	☐	☐	☐	☐
6. Removed trim if possible	☐	☐	☐	☐	☐
7. Selected appropriate protection material for area	☐	☐	☐	☐	☐
8. Applied tape to dry surface at appropriate temperature	☐	☐	☐	☐	☐
9. Allowed tape to follow contours naturally, without stretching	☐	☐	☐	☐	☐
10. Selected appropriate primer for type of repair	☐	☐	☐	☐	☐
11. Mixed and applied primer in accordance with product manufacturer's recommendations	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.2: Surface Preparation

Competency 5.2.11:	Apply two-component finishing filler to minor surface imperfections
Competency 5.2.13:	Dry sand area to which two-component finishing filler has been applied

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Apply two-component finishing filler to minor surface imperfections, and dry-sand area
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.11/ 5.2.13

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when applying two-component finishing filler to minor surface imperfections and dry-sanding area. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Two-component fillers have replaced lacquer-based glazing putty as the product of choice for filling in ***minor*** imperfections. These products do not have the filling properties of traditional fillers, however, and should not be used to fill in dents and dings.

2. These fillers usually have a polyester-based resin, dry quickly, have no shrinkage, and can be applied over any sanded surface, including paints and primers.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparing Two-Component Filler	2. Two components: • Filler • Hardener Mix two components thoroughly in accordance with manufacturer's specifications.
3. Applying Two-Component Fillers	3. Apply only to minor imperfections (e.g., pinholes, sand scratches) as this product has very little filling properties. Firmly press into imperfections using clean squeegee or spreader.
4. Sanding Two-Component Fillers	4. Dry-sand filler using 180-grit to 400-grit sandpaper. Sand until imperfections are removed and filler is smooth and level with surrounding surface.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on the history of filling materials and the composition of various types of fillers. The applied communications teacher could help students in locating and interpreting information about fillers in MSDSs.

Review:

Ask students review questions such as the following:

1. When would you use a two-component filler?
2. What type of resin are two-component body fillers based on?

Application:

1. Ask students to compare traditional fillers and glazing putty to two-component fillers and list the desirable and undesirable features of each.
2. As students practice applying two-component filler to panels supplied in the lab, quiz them individually on the process (e.g., ask them how they know when the two components have been "thoroughly" mixed).

Evaluation:

√ The student will apply two-component finishing filler to minor surface imperfections and dry-sand area. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.11/5.2.13.

Competency 5.2.11: Apply two-component finishing filler to minor surface imperfections

Competency 5.2.13: Dry sand area to which two-component finishing filler has been applied

Performance Checklist

In applying two-component finishing filler to minor surface imperfections and dry-sanding area, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Mixed hardener and filler thoroughly in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
4. Applied mixture only to minor imperfections	☐	☐	☐	☐	☐
5. Ensured that squeegee or spreader was clean	☐	☐	☐	☐	☐
6. Firmly pressed mixture into imperfections using squeegee or spreader	☐	☐	☐	☐	☐
7. Dry-sanded area using appropriate grade of sandpaper and standard procedures	☐	☐	☐	☐	☐
8. Dry-sanded until area met the following criteria:					
a. Imperfections had disappeared	☐	☐	☐	☐	☐
b. Area was smooth	☐	☐	☐	☐	☐
c. Area was level	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.2: Surface Preparation

Competency 5.2.14:	Remove dust from area to be refinished, including cracks or moldings of adjacent areas
Competency 5.2.15:	Clean area to be refinished using a final cleaning solution
Competency 5.2.16:	Remove, with a tack rag, any dust or lint particles from the area to be refinished

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Dust, clean, and tack off repair area
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.14–5.2.16

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when dusting, cleaning, and tacking off repair areas. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. What's the first thing a customer sees when he or she picks up a refinished vehicle? The paint job, of course. If the paint work has been done properly, you will have a happy customer.

2. Most paint defects are the result of poor preparation; they happen before the refinishing process even begins. It is during preparation that you should take those extra precautions: cleaning all dust and dirt from the repair area, cleaning the area with solvent, and double-checking your work. Poor preparation can cost you and the shop money, time, and a loss of customer satisfaction.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Removing Dust and Dirt from Repair Area	2. Use an air blower to remove dust and dirt from the panel, especially around trim, moldings, jamb areas, and crevices. Always wear eye protection during this process. Never use over 40 psi of air pressure.
3. Cleaning Repair Area	3. Final cleaning should be done using a grease and wax remover. Use one towel soaked with cleaner to float grease, wax, and other contaminants to the surface. Wear rubber gloves and eye protection. Dry with a clean, dry cloth. **Caution:** Do not touch panel with your bare hands after cleaning because the oil in your skin will contaminate the surface.
4. Tacking Off Repair Area	4. A clean tack cloth should be used to remove dust and lint that may remain on the surface. Unfold tack cloth, and layer it into a soft pile in your hand. Gently wipe tack cloth over repair area, without applying any pressure.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on air pressure and force, air flow (in a paint booth), the chemical properties of solvents, and the effect of skin oils on clean vehicle surfaces.

Review:

Ask students review questions such as the following:

1. How should dust and dirt be removed prior to refinishing?
2. Why is it important not to touch a vehicle after you have cleaned and tacked it off?
3. What is a tack cloth, and what is it used for?

Application:

1. Provide students with a variety of previously painted vehicles and/or panels, and ask them to inspect each one and identify areas with problems caused by improper preparation techniques.
2. As students practice dusting, cleaning, and tacking off a repair area, quiz them individually on the process (e.g., ask them how many psi of air pressure should be used in blowing off dust and dirt).

Evaluation:

√ The student will dust, clean, and tack off repair area. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.14–5.2.16.

Competency 5.2.14: Remove dust from area to be refinished, including cracks or moldings of adjacent areas
Competency 5.2.15: Clean area to be refinished using a final cleaning solution
Competency 5.2.16: Remove, with a tack rag, any dust or lint particles from the area to be refinished

Performance Checklist

In dusting, cleaning, and tacking off repair area, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Removed dust and dirt completely from repair area	☐	☐	☐	☐	☐
4. Used no more than 40 psi of air pressure	☐	☐	☐	☐	☐
5. Used grease and wax remover to float contaminants to surface	☐	☐	☐	☐	☐
6. Dried with clean, dry cloth	☐	☐	☐	☐	☐
7. Removed remaining dust and lint by wiping gently with a clean tack cloth	☐	☐	☐	☐	☐
8. Did not touch panel with bare hands after cleaning	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**_____________

Competency 5.2.17:	Apply suitable sealer to the area being refinished when sealing is needed or desirable
Competency 5.2.18:	Scuff sand to remove nibs or imperfections from a sealer

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Apply sealer and remove any nibs or imperfections by scuff-sanding
Criteria:	In accordance with the criteria in the checklist for Competencies 5.2.17/ 5.2.18

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when applying sealers and removing any nibs or imperfections by scuff-sanding. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Although a sealer is not required for every refinish operation, there are several situations in which a suitable sealer will be required:
   - Use of a light color over a dark primer or color
   - Use of a sealer to improve adhesion and color holdout and minimize sand-scratch swelling
   - Use of a tinted sealer to reduce the number of coats needed to achieve correct *hiding* of the color underneath (i.e., the color being applied hides, or covers, the underlying surface)
2. Always follow the manufacturer's recommendations! Never assume you know more than the paint manufacturer.

References:

Service manuals; technical service bulletins (TSBs); product information manuals from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Sealer Types and Colors	2. Lacquer-based sealers: • Used with lacquer-based topcoats • Can also be used with some basecoats/clear topcoats • Very fast-drying • Not recommended for use over bare metal Urethane and enamel-based sealers: • Used with urethane and enamel topcoats • Dry more slowly • Are usually nonsanding sealers **Key Point:** Lacquers cannot be applied over enamel-based sealers.
3. Sealer Colors	3. Colors include light or dark reds, grays, whites, and blacks. Other sealers are tinted to match topcoat.

Presentation Outline	Steps to Cover/Key Points to Make
4. Applying Sealers	4. Identify number of coats, air pressure, etc., in accordance with paint manufacturer's recommendations. Always use the proper respirator and personal protective equipment as required. Application area: • Seal entire panel when refinishing complete panels. • Seal just the repair areas when doing spot or blending refinishing.
5. Removing Nibs or Imperfections	5. Scuff-sand using dry sandpaper with a grade of 500- to 600-grit. Sand by hand until smooth, using a block or foam pad. Be careful to remove imperfections from surface without sanding through the sealer. If imperfections cannot be removed in this manner, it will be necessary to reapply sealer.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide information on the chemical characteristics of sealers and topcoats and on paint tints and their origins (organic, manufactured). The applied mathematics teacher could work with students in using formulas to determine volume, mixing ratios, and coverage of products.

Review:

Ask students review questions such as the following:

1. When should a sealer be used?
2. Should sealers be applied over bare metal? Why or why not?
3. How does the use of a tinted sealer aid the paint technician?

Application:

1. Have students locate and review the latest material from paint manufacturers on the use of sealers in refinishing. Then ask them to summarize, in writing, the manufacturers' recommendations and key guidelines (e.g., when tinted sealers should be used).

2. Have students apply a light gray sealer to one half of a test panel and a tinted sealer to the other half. Then ask them to add a topcoat in a color similar to that of the tinted sealer. Ask them to summarize their findings and results in writing.

Evaluation:

√ The student will apply sealer and remove any nibs or imperfections by scuff-sanding. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.2.17/5.2.18.

Competency 5.2.17: Apply suitable sealer to the area being refinished when sealing is needed or desirable
Competency 5.2.18: Scuff sand to remove nibs or imperfections from a sealer

Performance Checklist

In applying sealer and removing any nibs or imperfections by scuff-sanding, the student—

	1	**2**	**3**	**4**	**5**
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Determined appropriate type of sealer to use	☐	☐	☐	☐	☐
4. Determined appropriate color of sealer to use	☐	☐	☐	☐	☐
5. Applied sealer in accordance with manufacturer's recommendations (e.g., number of coats, air pressure)	☐	☐	☐	☐	☐
6. Scuff-sanded the sealer by hand with appropriate sandpaper grit	☐	☐	☐	☐	☐
7. Removed all nibs or imperfections without sanding through sealer	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.2: Surface Preparation

Competency 5.2.21: Prepare adjacent panels for blending

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Prepare adjacent panels for blending
Criteria:	In accordance with the criteria in the checklist for Competency 5.2.21

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when preparing adjacent panels for blending. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When refinishing a vehicle, it is often necessary to blend an adjacent panel to achieve a correct color match.
2. The blending technique is used with lacquer paints and basecoats/clearcoats. Since some lacquers are high in VOCs and are rarely used, we will focus on basecoats/clearcoats.
3. Product manufacturers recommend blending the basecoat but clearcoating entire panels to achieve color match.

References:

Service manuals; technical service bulletins (TSBs); paint color books and charts; product information manuals from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Cleaning Panels	2. Thoroughly clean panel with soap and water. Then clean with a wax and grease remover.
3. Sanding Panels	3. **Key Point:** Protect or remove moldings and trim prior to sanding (5.2.1). Sand panel using a 1200- to 1500-grit sandpaper or scuff pad equivalent to 1200- to 1500-grit. Do not sand through topcoat. Be sure to sand all edges.
4. Masking Panels	4. Mask panel as needed (5.2.8)
5. Performing Final Cleaning	5. Clean with wax and grease remover (no soap and water).
6. Applying Adhesive Promoter	6. Adhesion promoters, as their name suggests, promote adhesion of paint to the surface to which it is being applied. Some products require that an adhesion promoter be sprayed onto the panel prior to refinishing: • Check product manufacturer's recommendations concerning the use of adhesion promoters. • Tack off panel (5.2.16). • Apply adhesion promoter if required.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover the chemical properties of adhesion promoters that increase adhesion of topcoat and the properties of OEM or cured insoluble finishes that prevent adhesion of topcoat. The applied mathematics teacher could work with students in using formulas to determine volume and mixing ratios.

Review:

Ask students review questions such as the following:

1. Why are panels blended?
2. What grit (sandpaper or scuff pad) is recommended for use in sanding before blending?
3. What blending technique do paint manufacturers recommend?

Application:

1. Provide students with practice panels, and have them mask and final-prep them for blending.
2. As students practice sanding a panel for blending, quiz them individually on the process (e.g., ask them to demonstrate sanding the panel without sanding through the topcoat).

Evaluation:

√ The student will prepare adjacent panels for blending. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.2.21.

Competency 5.2.21: Prepare adjacent panels for blending

Performance Checklist

In preparing adjacent panels for blending, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Cleaned panels thoroughly in accordance with standard procedure	☐	☐	☐	☐	☐
4. Selected appropriate grit of sandpaper or comparable scuff pad	☐	☐	☐	☐	☐
5. Sanded panels without sanding through topcoat	☐	☐	☐	☐	☐
6. Sanded all edges	☐	☐	☐	☐	☐
7. Masked panel if necessary	☐	☐	☐	☐	☐
8. Performed final cleaning in accordance with standard procedure	☐	☐	☐	☐	☐
9. Applied adhesion promotion in accordance with manufacturer's recommendations	☐	☐	☐	☐	☐
10. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 5.3.3: Check and adjust operation of HVLP (high volume, low pressure) or LVLP (low volume, low pressure) spray guns

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Check and adjust operation of HVLP spray guns
Criteria:	In accordance with the criteria in the checklist for Competency 5.3.3

Introduction:

General Introductory Techniques: Share personal experiences you have had when checking and adjusting operation of HVLP spray guns in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Federal and state EPA regulations limit the amount of volatile organic compounds (VOCs) that can be released into the air. Thus, the need to reduce the VOCs used in collision repair is a major concern to refinish technicians.

2. In fact, in some states, such as California, the use of low-VOC refinish materials and high-volume, low-pressure (HVLP) equipment is mandatory.

3. *Transfer efficiency* is the amount of paint that is actually applied to a surface. Conventional spray equipment has a transfer efficiency of 30%–40%, whereas HVLP equipment has a transfer efficiency of 70%.

References:

Service manuals; technical service bulletins (TSBs); spray gun troubleshooting chart (available in many major sources such as *MOTOR Auto Body Repair*). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safety Practices	2. Respirators must be worn whenever spraying paint.
3. HVLP System Operation	3. Check operating manual for the specific HVLP equipment. Determine the appropriate fluid tip, air cap, and air pressure setting for the type of material to be applied.
4. Establishing Proper Paint Flow	4. Make sure the knob/needle for adjusting fluid flow is closed. Open the knob/needle slowly until desired fluid flow—per manufacturer's specifications—is reached (5.3.4). If paint flow is inadequate with knob/needle fully open, increase cup pressure or try a larger paint tip. **Key Point:** Watch for paint leakage around the cup. Because the cup in an HVLP system is under pressure, it is more likely to leak around the seal than a siphon cup is.

Presentation Outline	Steps to Cover/Key Points to Make
5. Adjusting Air Cap Pressure	5. Air cap pressure may at times be inadequate even when the source of the air pressure is working at full capacity. Cap pressure can be brought to desired levels as follows: • Regulator devices can be removed or replaced by those that allow more air pressure. • Shorter or larger hoses can be added to the system. • An air cap with smaller holes can be used.
6. Checking Adjustments	6. Test the equipment by making several spray passes on test panels. Adjust as needed.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons on air pressure, friction, atomization, VOCs, EPA, and pollution and its environmental impacts. The applied mathematics teacher could help students with measurement of air flow and pressure increases and decreases.

Review:

Ask students review questions such as the following:

1. Define *atomization*. Why is it important?
2. Describe how HVLP equipment operates.
3. What is *transfer efficiency*?

Application:

1. Set up two stations: one conventional, and one HVLP. Have students experiment with both, compare the results, and then chart the advantages and disadvantages of each system.
2. Have students research environmental impacts, VOCs, EPA regulations, and standards for HVLP systems in different states (e.g., if the class has 15 students, each student could be assigned to research 4 states).

Evaluation:

√ The student will check and adjust operation of HVLP spray guns. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.3.3.

Competency 5.3.3: Check and adjust operation of HVLP (high volume, low pressure) or LVLP (low volume, low pressure) spray guns

Performance Checklist

In checking and adjusting operation of HVLP spray guns, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Checked operating manual for specific HVLP system	☐	☐	☐	☐	☐
4. Selected appropriate components/settings for the type of paint being applied, including—					
a. Fluid tip	☐	☐	☐	☐	☐
b. Air cap	☐	☐	☐	☐	☐
c. Air pressure settings	☐	☐	☐	☐	☐
5. Established proper paint flow by slowly adjusting knob/needle	☐	☐	☐	☐	☐
6. Adjusted cup pressure using an accepted method, if needed	☐	☐	☐	☐	☐
7. Checked adjustments by making several test passes	☐	☐	☐	☐	☐
8. Made any final adjustments necessary	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.3: Spray Gun and Related Equipment Operation

Competency 5.3.4:	Set up (fluid needle, nozzle, and cap), adjust, and test spray gun using fluid, air, and pattern control valves

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Set up, adjust, and test a spray gun using fluid, air, and pattern control valves
Criteria:	In accordance with the criteria in the checklist for Competency 5.3.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when setting up, adjusting, and testing spray guns using fluid, air, and pattern control valves. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. The selection and setup of spray equipment is critical in the application of the materials being sprayed.

2. There is not a single paint gun that will spray ***all*** given products (paints, primers, sealers, clearcoats) due to their varying degrees of viscosity and the need to properly atomize each product.

3. *Atomization* is the breaking up of the particles of paint using air pressure.

References:

Service manuals; technical service bulletins (TSBs); product information manuals from paint manufacturers; spray gun troubleshooting chart (available in many major sources such as *MOTOR Auto Body Repair*). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Spray Gun Parts	2. Three major parts: • Fluid needle ~ Directs the flow of material from the gun to the air stream • Nozzle (also called the fluid tip) ~ Holds the fluid needle ~ Starts atomization process (breakup of material into pieces) • Air cap ~ Screws over the nozzle ~ Completes atomization process These parts are available in different sizes to fit the type and viscosity of the material being sprayed. Select the appropriate type for the material in accordance with manufacturer's recommendations.
3. Adjusting Spray Gun	3. Adjustments are made in three areas: • Pattern control ~ When the pattern control is closed, the spray pattern is round. ~ When the pattern control is open, the spray pattern becomes oblong.

Presentation Outline	Steps to Cover/Key Points to Make
	• Fluid control ~ Controls the amount of fluid that flows through the nozzle (or fluid tip). • Air pressure ~ The more open the air valve, the greater the air pressure. **Key Point:** Air pressure should always be measured at the gun (***not*** at the wall). Follow manufacturer's specifications for viscosity, air pressure and fluid flow for material being sprayed.
4. Testing Spray Gun	4. After setting the air pressure, pattern size, and fluid flow, test the spray pattern on a piece of masking paper attached to a vertical surface. Hold the gun the recommended distance from the masking paper Pull trigger and release immediately. Burst of paint should leave an oblong shape on the masking paper. Inspect the texture of the spray pattern: • If drops are too large, decrease fluid control and/or raise air pressure 5 psi. • If drops are too fine or dry, open the fluid control knob and/or decrease air pressure 5 psi. Continue this process until desired pattern and texture are achieved. Turn the air cap 90° so that the air horns are straight up and down. Spray on test panel or masking paper until paint runs—called *flooding*. • If runs are even across test panel, the spray gun has been set up correctly. • If runs are uneven, adjust spray pattern and/or air pressure to achieve a balanced spray pattern.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could cover such concepts as atomization, viscosity, friction, and force (pressure). The applied mathematics teacher could provide help in measuring viscosity, volume, and air flow.

Review:

Ask students review questions such as the following:

1. What is atomization?
2. What are the functions of the spray gun's nozzle (fluid tip), fluid needle, and air cap?
3. What steps should you follow in testing a spray pattern?
4. What is the flooding technique, and why is it used?

Application:

1. Provide students with various types of materials that could be sprayed, and ask them to select the appropriate spray gun nozzle, fluid needle, and air cap for each type.
2. Have students set up and test spray patterns using various types of materials and spray guns. Then have them compare their results.

Evaluation:

√ The student will set up, adjust, and test a spray gun using fluid, air, and pattern control valves. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.3.4.

Competency 5.3.4: Set up (fluid needle, nozzle, and cap), adjust, and test spray gun using fluid, air, and pattern control valves

Performance Checklist

In setting up, adjusting, and testing a spray gun using fluid, air, and pattern control valves, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct size and type of fluid needle, nozzle, and air cap for material being sprayed	☐	☐	☐	☐	☐
3. Installed fluid needle, nozzle, and air cap according to manufacturer's recommendations	☐	☐	☐	☐	☐
4. Adjusted spray gun in accordance with manufacturer's recommendations, including—					
a. Pattern control	☐	☐	☐	☐	☐
b. Fluid control	☐	☐	☐	☐	☐
c. Air pressure	☐	☐	☐	☐	☐
5. Tested spray gun in accordance with manufacturer's recommendations	☐	☐	☐	☐	☐
6. Rechecked spray pattern using flooding technique	☐	☐	☐	☐	☐
7. Adjusted spray gun until balanced spray pattern was achieved	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.4: Paint Mixing, Matching, and Applying

Competency 5.4.1: Determine type and color of paint already on vehicle by manufacturer's vehicle information label

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Determine type and color of paint already on vehicle using manufacturer's vehicle information label

Criteria: In accordance with the criteria in the checklist for Competency 5.4.1

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when determining type and color of paint already on vehicles using manufacturer's vehicle information label. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Display (and pass around) a paint product manufacturer's manual, and point out that the manual contains ***every*** major vehicle manufacturer's paint codes for the past ***20 years***.
2. Discuss why it is so important to match paint colors and types ***exactly*** when refinishing vehicles:
   - So many types of finishes (e.g., single-stage paints, basecoats, clearcoats, enamels, water-bornes, urethanes)
   - So many colors with minute variations

References:

Service manuals; technical service bulletins (TSBs); product information manuals from paint manufacturers (once purchased, free updates are provided annually); collision estimating guides. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Establishing Make, Model, and Year of Vehicle	2. Possible sources for this information: • Work order • Customer information • Label on left door or pillar post • VIN (Vehicle Information Number)
3. Locating the Vehicle Information Label	3. Sources of location information: • Paint product manufacturer's manuals • Vehicle service manual Use index to locate the make, model, and year of the vehicle in question. Pages for that vehicle will tell where the label is located on that vehicle (e.g., door, pillar post, core support, trunk, cowl panel). Manual will also show examples of labels and where the paint code is located on each.

Presentation Outline	Steps to Cover/Key Points to Make
4. Referencing the Paint Code Back to the Paint Product Manufacturer's Manual	4. Tips for how to locate information in manual: • Typical organizations (e.g., paints are listed together by year, not by vehicle) • Differences between manufacturers • Importance of using exact make, model, and year of vehicle in looking up paint code (e.g., paint codes are reused, so a 1992 paint code may designate a completely different color in 1997; cars and trucks may have the same paint codes but different colors)

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on locating information in paint product manufacturers' manuals and vehicle service manuals.

Review:

Ask students review questions such as the following:

1. What is the first—most essential—piece of information you need in order to find the vehicle's paint code?
2. Name typical locations of vehicle information labels?
3. Three vehicles are blue. The three vehicles have the same paint code. Are the three colors the same blue? Why or why not?

Application:

1. Give students a set of vehicle information labels and the vehicle make, model, and year for each. Ask them to find the color and type of finish specified.
2. Have students locate the vehicle information labels on four to five vehicles, identify the paint code, and then find the color and type of finish specified.

Evaluation:

√ The student will determine type and color of paint already on vehicle using manufacturer's vehicle information label. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.4.1.

Competency 5.4.1: Determine type and color of paint already on vehicle by manufacturer's vehicle information label

Performance Checklist

In determining type and color of paint already on vehicle using manufacturer's vehicle information label, the student—

	1	2	3	4	5
1. Referred to appropriate reference manuals	☐	☐	☐	☐	☐
2. Accurately identified vehicle make, model, and year	☐	☐	☐	☐	☐
3. Located vehicle information label	☐	☐	☐	☐	☐
4. Accurately identified each paint code	☐	☐	☐	☐	☐
5. Used codes to locate correct paint type and color in paint product manufacturers' manuals	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.4: Paint Mixing, Matching, and Applying

Competency 5.4.3: Use spray technique (gun arc, gun angle, gun distance, gun speed, and spray pattern overlap) appropriate for finish being applied

Competency Development Guide

Objective:

Condition:	Provided with a paint gun and a panel, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Use spray technique appropriate for finish being applied
Criteria:	In accordance with the criteria in the checklist for Competency 5.4.3

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility in selecting and using spray techniques appropriate for finishes being applied. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Explain that experienced refinish technicians develop a style of their own, but the basics used are always the same.

2. Stress that in the vocational program, all students will use the same style in order to master the basics. As they later become experienced on the job, their own preferences will emerge.

References:

Service manuals; technical service bulletins (TSBs); product information manuals from paint manufacturers; spray gun troubleshooting chart (available in many major sources such as *MOTOR Auto Body Repair*). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. To prevent accumulation of products in lungs or absorption into blood stream, need to use respiratory protection. When a car is being spray-painted, must wear appropriate personal protective equipment (PPE) for product being applied.
3. Gun Arc	3. Gun should be arced only for spot refinishing; otherwise it should be held at a constant distance from the surface.
4. Gun Angle	4. Gun must always be held parallel to the surface being painted.
5. Gun Distance	5. For most products, gun should usually be held 8"–10" from the surface being painted. However, distance can vary with gun speed and type of product being applied. **Key Point:** Once distance is selected, it should remain constant.
6. Gun Speed	6. Speed used should allow product to be applied evenly and smoothly: • Dry spots = too fast • Runs and sags = too slow

Presentation Outline	Steps to Cover/Key Points to Make
7. Spray Pattern Overlap	7. *Spray pattern* = width of the spray Overlap standard is typically 50%, but need to check manufacturer's specifications.
8. Variations Based on Finish Being Applied	8. Most elements are fairly constant; however, gun speed will vary for primers vs. paints.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can work with students on such concepts as (1) the effect of speed on the amount of coverage (watering the lawn is a good example) and (2) motion (arcing a hand-held device is the natural motion; need to use body to hold gun straight, steady, and at a constant distance).

Review:

Ask students review questions such as the following:

1. What happens to coverage if you vary your gun speed as you paint?
2. If you allow the gun to arc, what happens to coverage?
3. True or False: Spray pattern overlap is always 50%.
4. Using two sheets of paper to demonstrate, show what a 50% overlap would look like.

Application:

1. Place water/food coloring mixture in gun, and demonstrate for students what happens when gun adjustments are made.
2. Tape masking paper to the walls, and have students practice spray techniques using guns filled with water/food coloring mixture.
3. Tape masking paper to the walls, and have students practice spray techniques using old or donated paint. **Caution**: Do not let them spray on paint booth walls.

Evaluation:

√ The student will use spray technique appropriate for finish being applied. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.4.3.

Competency 5.4.3: Use spray technique (gun arc, gun angle, gun distance, gun speed, and spray pattern overlap) appropriate for finish being applied

Performance Checklist

In using spray technique appropriate for finish being applied, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Maintained gun arc appropriate for area of surface being refinished	☐	☐	☐	☐	☐
3. Maintained angle of gun parallel to surface	☐	☐	☐	☐	☐
4. Held gun at constant distance in accordance with product manufacturer's specifications	☐	☐	☐	☐	☐
5. Maintained a speed that produced a smooth, even finish, with proper product buildup	☐	☐	☐	☐	☐
6. Maintained a spray pattern overlap of 50%	☐	☐	☐	☐	☐
7. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name_______________________________________**Date**_____________

Unit 5: Painting and Refinishing

Subunit 5.4: Paint Mixing, Matching, and Applying

Competency 5.4.4: Apply selected product on test and let-down panel in accordance with manufacturer's recommendations; check for color match

Competency Development Guide

Objective:

Condition:	Provided with a panel, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Apply selected product on a test or let-down panel, and check for color match
Criteria:	In accordance with the criteria in the checklist for Competency 5.4.4

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when applying selected product on a test and let-down panel and checking for color match. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Ask students—
   - If you've carefully identified the paint code and secured the correct paint, why would you need to try it on a test or let-down panel to make sure it's right?

   Reasons: It's cost-effective. It's very expensive to make a mistake on a real vehicle.

2. Ask students—
   - Why wouldn't the paints match if you selected the correct paint?

   Possible reasons for variations: type of equipment, age of vehicle, paint manufacturer, number of coats applied, spray technique, how fast overspray comes back on surface in particular paint booth, speed of reducers—fast-dry, slow-dry—used in the paint, type/color of primers/sealers used.

References:

Service manuals; technical service bulletins (TSBs); product information manuals from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Critical Safe Practices	2. To prevent accumulation of products in lungs or absorption into blood stream, need to use respiratory protection. When a car is being spray-painted, must wear appropriate personal protective equipment (PPE) for product being applied.
3. Test/Let-Down Panels	3. Paint chips in books are not true representatives of the color. *Test panels* are designed to accurately reproduce how the paint will look on the vehicle. They allow you to compare the paint you bought to the paint on the vehicle. *Let-down panels* are test panels with a different number of coats on different sections. Test and let-down panels are usually made of metal and should be 6" x 6" or larger. Once painted, they can be saved for future reference in matching paint to a particular vehicle.

Presentation Outline	Steps to Cover/Key Points to Make
4. Testing Process	4. Duplicate entire paint process exactly (primers, paint, clearcoat, technique, equipment). Let paint dry. Compare panel to vehicle. **Key Point:** Examine both panel and vehicle with same lighting method. Natural daylight is best.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could explain how paint is made (ingredients, process) since you can't match paints well without this knowledge. Study of colors would also be useful (e.g., on a "black" GM car, the paint is really black, blue, yellow, red, and violet since black has a very weak pigment). The applied science teacher could also cover how ultraviolet rays fade paint, refraction of light in color comparisons, and how type of light (fluorescent, natural, incandescent) can make colors shift in hue.

Review Questions:

1. What is the difference between a test panel and a let-down panel?
2. Once they are test-painted, how can these panels be useful in the future?
3. What factors can affect paint match?

Application:

1. Give students a teacher-painted panel as a standard, and have each student paint a test panel trying to match the standard.
2. Label the panels produced, and have students try to pick the one that most closely matches the standard. Have students discuss the variations between panels and identify possible causes.

Evaluation:

√ The student will apply selected product on a test or let-down panel and check for color match. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.4.4.

Competency 5.4.4: Apply selected product on test and let-down panel in accordance with manufacturer's recommendations; check for color match

Performance Checklist

In applying selected product on a test or let-down panel and checking for color match, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Sprayed panel in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
3. Compared panel to vehicle	☐	☐	☐	☐	☐
4. Identified obvious variations in color	☐	☐	☐	☐	☐
5. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Competency 5.4.5: Apply single-stage topcoat for refinishing

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Apply a single-stage topcoat for refinishing
Criteria:	In accordance with the criteria in the checklist for Competency 5.4.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when applying single-stage topcoats in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. The vehicle must be prepped before applying the single-stage topcoat.
2. The single-stage topcoat is used mainly for panel or overall refinishing (not spotting or blending). Its purposes are to protect the vehicle and give it a shine.
3. It is called *single-stage* because it requires no clearcoat to produce a shine.
4. Single-stage paints are used extensively on equipment and commercial vehicles (e.g., pickup trucks, delivery vans, heavy equipment, semis, school buses).

References:

Service manuals; technical service bulletins (TSBs); product information manuals from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Preparation	2. Mix paint in accordance with manufacturer's instructions. **Key Point:** Select proper reducers for spraying conditions (shop temperature, booth temperature). Strain paint before putting it in paint gun. Adjust paint gun in accordance with paint manufacturer's recommendations (5.3.4), including: • Air pressure • Fan control • Fluid control Tack off area to be sprayed (5.2.14–5.2.16). **Key Point:** Always use a clean tack rag for each refinishing job.

Presentation Outline	Steps to Cover/Key Points to Make
3. Painting the Surface	3. Apply paint in accordance with manufacturer's instructions, including: • Number of coats to apply • How wet to apply paint: ~ Dry coat—looks rough and grainy (orange peel) ~ Medium-wet coat—looks fairly smooth, with minimal orange peel ~ Full-wet coat—looks very smooth, with little or no orange peel **Key Point:** How wet to apply color is a skill that is developed with time.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could review volume and mixing ratios with students. The applied science teacher could cover chemical reactions, molecular structures (e.g., of paints, reducers, catalysts, hardeners).

Review:

Ask students review questions such as the following:

1. Why is this type of topcoat called *single-stage*?
2. Why are single-stage topcoats used?
3. Why is it important to follow the manufacturer's instructions?

Application:

1. Have students develop a procedure sheet for applying single-stage topcoats that can be used to guide student practice in the shop.
2. Divide students into small groups, provide them with practice panels, and ask them to mix and apply single-stage topcoats using different paints.

Evaluation:

√ The student will apply a single-stage topcoat for refinishing. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.4.5.

Competency 5.4.5: Apply single-stage topcoat for refinishing

Performance Checklist

In applying a single-stage topcoat for refinishing, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Mixed paint in accordance with manufacturer's instructions	☐	☐	☐	☐	☐
4. Strained paint before filling paint gun	☐	☐	☐	☐	☐
5. Made each of the following paint gun adjustments in accordance with manufacturer's recommendations:					
a. Air pressure	☐	☐	☐	☐	☐
b. Fan control	☐	☐	☐	☐	☐
c. Fluid control	☐	☐	☐	☐	☐
6. Adequately tacked off area to be sprayed	☐	☐	☐	☐	☐
7. Applied paint in accordance with manufacturer's instructions	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.4: Paint Mixing, Matching, and Applying

Competency 5.4.6: Apply basecoat/clearcoat for spot and panel blending or overall refinishing

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Apply basecoat/clearcoat for spot and panel blending or overall refinishing
Criteria:	In accordance with the criteria in the checklist for Competency 5.4.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when applying basecoat/clearcoat for spot and panel blending or overall refinishing in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. When refinishing with basecoats/clearcoats, it will be necessary to clearcoat entire panels, even if you are blending or spot refinishing a repair.
2. Therefore, it is crucial to refer to manufacturer's specifications for information for each specific operation.

References:

Service manuals; technical service bulletins (TSBs); product information manuals from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Note: Although they share some common elements, competencies 5.4.5 and 5.4.6 should be taught separately to avoid student confusion.

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Determining Type of Repair Needed	2. Four types of repair: • Spot—paint will be applied over repair area only • Panel—paint will be applied to complete panel • Blending—paint will be applied to two or more adjacent panels • Overall—complete vehicle will be refinished
3. Preparation	3. Mix paint in accordance with manufacturer's instructions. Fill and adjust gun (5.3.4).
4. Applying Basecoat	4. Apply basecoat in accordance with manufacturer's instructions, allowing for— • hiding to be achieved (i.e., substrate surface is not visible through color); and • sufficient flash time (drying time) between coats.

Presentation Outline	Steps to Cover/Key Points to Make
	For blending and spot refinishing, each successive coat of paint must extend past previous coat to achieve a tapered repair edge (usually 3–4 coats). For panel and overall refinishing, each panel must receive the same number of coats (applied to entire panel or vehicle). **Key Point:** Do not sand the basecoat before application of clearcoat.
5. Applying Clearcoat	5. Mix clearcoat in accordance with manufacture's instructions. Fill and adjust gun (5.3.4). Clearcoats should be applied to complete panels only. This prevents the possibility of paint product failure (e.g., lack of adhesion, poor gloss). Follow manufacturer's instructions for number of coats and flash time. **Key Point:** Clean spray guns before and after each spraying operation.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover algebraic formulas for calculating surface area and volume (how much material is needed for a specific repair), mixing ratios, and measuring paint film thickness (mils).

Review:

Ask students review questions such as the following:

1. Why should the entire panel be clearcoated in blending or spot refinishing?
2. What method should be used for blending or spot refinishing of panels?

Application:

1. Have students review and compare spot and panel blending methods specified by several different product manufacturers. Then have them do the same for overall refinishing.

2. Have students refinish a panel completely, duplicating overall refinishing procedures. Then create a small damage area, and have them repair it by spotting and blending.

Evaluation:

√ The student will apply basecoat/clearcoat for spot and panel blending or overall refinishing. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.4.6.

Competency 5.4.6: Apply basecoat/clearcoat for spot and panel blending or overall refinishing

Performance Checklist

In applying basecoat/clearcoat for spot and panel blending or overall refinishing, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Determined type of refinishing operation	☐	☐	☐	☐	☐
4. Mixed basecoat in accordance with manufacturer's instructions	☐	☐	☐	☐	☐
5. Prepared gun correctly (filled, adjusted)	☐	☐	☐	☐	☐
6. Applied basecoat using procedure appropriate for type of refinishing operation (spot, blending, panel, overall)	☐	☐	☐	☐	☐
7. Allowed for sufficient drying time	☐	☐	☐	☐	☐
8. Achieved hiding	☐	☐	☐	☐	☐
9. Mixed clearcoat in accordance with manufacturer's instructions	☐	☐	☐	☐	☐
10. Prepared gun correctly (cleaned, filled, adjusted)	☐	☐	☐	☐	☐
11. Applied clearcoat in accordance with manufacturer's specifications concerning number of coats and flash time	☐	☐	☐	☐	☐
12. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.4: Paint Mixing, Matching, and Applying

Competency 5.4.7: Color sand, buff, and polish finishes where necessary

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Color-sand, buff, and polish finishes
Criteria:	In accordance with the criteria in the checklist for Competency 5.4.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when color-sanding, buffing, and polishing finishes in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Color-sanding is used to remove any defects in the refinished paint without damaging the surrounding surface. It can be done wet or dry, using hand or machine sanding techniques.

2. Buffing and polishing, too, can be done manually or by machine. The selection of the correct materials and methods is critical to achieving the desired finish and appearance.

References:

Service manuals; technical service bulletins (TSBs); product information (e.g., charts of imperfections related to techniques and materials) from paint manufacturers. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Color-Sanding Technique	2. Color-sanding is also known as *finesse finishing*. Color-sand refers to fine grades of sandpaper (usually 600-grit or finer). The color-sanding technique is used to remove minor imperfections (e.g., dirt, runs, sags).
3. Color-Sanding the Finish	3. Identify imperfections to be sanded. Select proper grit of sandpaper. **General Rule of Thumb:** • Use 600-grit or finer on single-stage paints. • Use 1000-grit or finer on two-stage paints. Select method (wet or dry) to be used. Sand imperfection until it disappears or is removed without damaging surrounding surface.

Presentation Outline	Steps to Cover/Key Points to Make
4. Buffing the Finish	4. Compound the area that was color-sanded: - Use heavier compound on single-stage paints. - Use microfinishing compound on two-stage paints (basecoat/clearcoat). Use buffer to remove marks and scratches left from color-sanding operation. You are ready for the next stage (polishing) when all sand scratches have been removed and there is a uniform, glossy finish.
5. Polishing the Finish	5. Select the polish or glaze that is appropriate for the finish. Put new pads on buffer. **Key Point:** Never use the same pads for compounds and polishes. Use buffer to remove swirl marks left from compounding. **Key Point:** Some hand-polishing may be necessary to remove all swirl marks. Your job is complete when the surface is free of imperfections and has a uniform gloss.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can cover the makeup of sandpaper and the role of friction and heat in compounding (sanding at high speed while increasing shine).

Review:

Ask students review questions such as the following:

1. What is the purpose of color-sanding?
2. What is the purpose of buffing?
3. What is the purpose of polishing?

Application:

1. Divide students into three groups, and assign each group one of the following topics: sandpaper, compounds, and polishes. Ask each group to research their topic and prepare a chart describing types, uses, and methods.
2. As students practice color-sanding, buffing, and polishing finishes, quiz them individually on the process (e.g., ask them to explain how they selected the sandpaper grit, compound, and polisher or glaze to use).

Evaluation:

√ The student will color-sand, buff, and polish finishes. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.4.7.

Competency 5.4.7: Color-sand, buff, and polish finishes where necessary

Performance Checklist

In color-sanding, buffing, and polishing finishes, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Identified all imperfections requiring sanding	☐	☐	☐	☐	☐
4. Selected appropriate sandpaper grit for surface	☐	☐	☐	☐	☐
5. Selected appropriate method (wet, dry) of color-sanding	☐	☐	☐	☐	☐
6. Removed imperfections completely without damaging surrounding surface	☐	☐	☐	☐	☐
7. Selected appropriate compound for surface	☐	☐	☐	☐	☐
8. Buffed surface in accordance with industry standard	☐	☐	☐	☐	☐
9. Selected appropriate polish or glaze for surface	☐	☐	☐	☐	☐
10. Polished surface in accordance with industry standard	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.4: Paint Mixing, Matching, and Applying

Competency 5.4.8:	Identify the types of rigid, semi-rigid, or flexible plastic parts to be refinished; determine the materials, preparation, and refinishing procedures
Competency 5.4.9:	Refinish rigid, semi-rigid, or flexible plastic parts

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Refinish rigid, semi-rigid, or flexible plastic parts
Criteria:	In accordance with the criteria in the checklist for Competencies 5.4.8/5.4.9

Introduction:

General Introductory Techniques: Share personal experiences you have had when refinishing rigid, semi-rigid, or flexible plastic parts in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Today's vehicles contain many types of plastic parts—both interior and exterior—that may require refinishing.

2. The type of plastic used and the recommended procedure for refinishing will vary depending on the manufacturer.

3. Most plastic parts are categorized as either rigid or flexible.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Identifying Types of Plastic Parts	2. Types of plastic parts: • Rigid (e.g., head lamp mounting panels) • Semi-rigid (e.g., windshield washer bottles) • Flexible (e.g., fascias and bumper covers) Identification methods: • Most parts are stamped (ISO codes) and can be identified by simply checking the stamp. • Manufacturer's specifications manual will also indicate what type of plastic each part is made of. • A burn test, which is not as accurate, can be used in the absence of ISO codes.

Presentation Outline	Steps to Cover/Key Points to Make
3. Selecting Refinishing Procedure/ Materials	3. Refer to manufacturer's specifications or paint supplier's recommendations for procedures and materials to use for refinishing a given part. General procedure: • Clean part using a plastic parts cleaner. • If part is new, it will not need a primer. • If part has been repaired, select appropriate primer. • Sand or scuff-sand part to be refinished. • Select appropriate topcoat, and determine level of gloss necessary. ~ Flat—interior parts ~ Semi-gloss—interior parts ~ Gloss—exterior parts
4. Refinishing Plastic Parts	4. Follow recommended refinishing procedures. Determine need for use of flex-additives. **General Rule of Thumb:** • A flex-additive is usually not needed on rigid plastic parts. • A flex-additive must be added for semi-rigid or flexible plastic parts to give the paint the needed elasticity. • Flex-additives must be added to the clearcoat, but not to the basecoat. Once refinished, part should match gloss/color of existing parts.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can cover types of plastic (thermosplastic or thermoset), chemical reactions, and molecular structure (e.g., changes when flex-additives are used).

Review:

Ask students review questions such as the following:

1. Why is it important to check manufacturer's specifications for materials and procedures?
2. Why are flex-additives used in paint? For what parts are they used?

Application:

1. Provide students with a variety of plastic parts, and ask them to classify them into rigid and flexible groups.
2. Obtain a variety of plastic parts from different manufacturers, provide each student with one plastic part, and ask students to identify the type of plastic they were given and the refinish method to use for that plastic.
3. Have students refinish the part they were given in the previous activity, using the procedure they identified.

Evaluation:

√ The student will refinish rigid, semi-rigid, or flexible plastic parts. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.4.8/ 5.4.9.

Competency 5.4.8:	Identify the types of rigid, semi-rigid, or flexible plastic parts to be refinished; determine the materials, preparation, and refinishing procedures
Competency 5.4.9:	Refinish rigid, semi-rigid, or flexible plastic parts

Performance Checklist

In refinishing rigid, semi-rigid, or flexible plastic parts, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly identified whether the part was flexible, rigid, or semi-rigid	☐	☐	☐	☐	☐
4. Identified proper procedure to follow using appropriate manual (manufacturer's or paint supplier's)	☐	☐	☐	☐	☐
5. Identified proper refinishing materials using appropriate manual (manufacturer's or paint supplier's)	☐	☐	☐	☐	☐
6. Refinished part in accordance with recommended procedures	☐	☐	☐	☐	☐
7. Ensured that refinished part had correct level of gloss/color	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 5.5.19: Identify dirt in the paint surface; determine the cause(s) and correct the condition

Competency Development Guide

Objective:

Condition:	Provided with a painted panel, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Identify dirt in the paint surface, determine the cause(s), and correct the condition
Criteria:	In accordance with the criteria in the checklist for Competency 5.5.19

Introduction:

General Introductory Techniques: Share personal experiences you have had in the collision repair facility when identifying dirt in the paint surface, determining the cause(s), and correcting the condition. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Pass around one painted panel with dirt and one panel without dirt, and ask students to identify the differences between panels.

   OR

   Pass around a panel with slight imperfections that will look good to students; then point out the imperfections.

2. Discuss the reasons for correcting small dirt problems (e.g., customer satisfaction, customer expectations, shop reputation, resale value of vehicle).

References:

Service manuals; technical service bulletins (TSBs); paint product manufacturers' recommendations and videos. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Identifying Dirt Problems	2. Inspect the surface, looking for different types of dirt problems (e.g., hair, dirt/dust, lint). **Key Points:** • Look very closely as you inspect. • Be careful to inspect each panel separately. • Dirt shows up best under fluorescent lights.
3. Determining Causes of Problems	3. Important to identify what is causing the dirt condition in order to minimize its reoccurrence. Prevention is cost- and labor-effective. Typical causes: • Dirt on uniform • Personal uncleanliness • Hair not properly covered • Dirty environment (paint booth, prep area) • Dirt on vehicle itself • Improper tacking off of vehicle • Dirty paint gun • Dirt in air lines

Presentation Outline	Steps to Cover/Key Points to Make
	Key Point: Tiny pieces of dirt are magnified by paint. Clearcoat magnifies it even more. **Remember:** If you can tell it was refinished, it wasn't done right.
4. Correcting Causes	4. Eliminate all identified sources of dirt. **Key Point**: Many causes can be eliminated if steps are followed in the first place. Don't rush jobs. **Remember:** The difference between a good job and a bad job is about 1 hour.
5. Correcting Dirt Condition	5. Determine sanding process (wet, dry) to use (advantages and disadvantages of each sanding process). Determine depth of sanding needed/possible. Dry- or wet-sand area (5.2.5/5.2.6/5.2.12) **Key Point:** If you sand through the clearcoat, you will have to refinish. Determine type of rubbing compound, buffing/polishing pads, and polish to use (5.4.7).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could discuss why dirt will show up best under fluorescent light.

Review:

Ask students review questions such as the following:

1. What is the #1 cause of dirt problems?
2. Why should you remove dirt from the refinished surface? What are the benefits?
3. What are the advantages and disadvantages of wet-sanding? dry-sanding?

Application:

1. Ask students to examine area/conditions in which refinishing will occur and then develop a plan for minimizing imperfections in the refinishing work.
2. As students practice removing dirt from a painted panel, quiz them individually on the process (e.g., ask to point out the location of dirt and/or to explain the process necessary to correct the condition).

Evaluation:

√ The student will identify dirt in the paint surface, determine the cause(s), and correct the condition. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.5.19.

Competency 5.5.19: Identify dirt in the paint surface; determine the cause(s) and correct the condition

Performance Checklist

In identifying dirt in the paint surface, determining the cause(s), and correcting the condition, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Referred to paint manufacturer's recommendations	☐	☐	☐	☐	☐
3. Located all imperfections caused by dirt	☐	☐	☐	☐	☐
4. Identified obvious sources of the dirt (e.g., carelessness in the preparation/refinishing process)	☐	☐	☐	☐	☐
5. Determined correct sanding process to use	☐	☐	☐	☐	☐
6. Determined depth of sanding needed/possible to remove dirt	☐	☐	☐	☐	☐
7. Selected the materials appropriate for the buffing and polishing process	☐	☐	☐	☐	☐
8. Sanded, buffed, and polished the surface so that it was—					
a. Free of dirt imperfections	☐	☐	☐	☐	☐
b. Restored to condition specified by instructor	☐	☐	☐	☐	☐
9. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.5: Paint Defects—Causes and Cures

Competency 5.5.27: Identify buffing-related imperfections (swirl marks, wheel burns); correct the condition

Competency Development Guide

Objective:

Condition: Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines

Behavior: Identify and correct buffing-related imperfections

Criteria: In accordance with the criteria in the checklist for Competency 5.5.27

Introduction:

General Introductory Techniques: Share personal experiences you have had when identifying and correcting buffing-related imperfections in the collision repair facility. Show videos that demonstrate the steps in these processes.

Competency-Specific Information:

1. Show students examples of buffing imperfections (illustrations, actual samples).
2. Explain how these imperfections happen (e.g., improper rubbing or polishing techniques, improper material selection).
3. Rubbing compounds are designed to be applied at a higher speed than polishes.

References:

Service manuals; technical service bulletins (TSBs); product material from paint manufacturers concerning kinds of compounds and techniques to use. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Identifying Buffing Imperfections	2. Two main types of imperfections: • Swirl mark—a circular imperfection on the topcoat; surface is smooth • Wheel burn—residue left on the surface of the topcoat
3. Correcting Swirl Marks	3. Remove by one of the following repolishing methods: • Use a polishing compound and a clean polishing pad. • Hand-polish.
4. Correcting Wheel Burns	4. Remove residue using one of the following methods: • Wash with soap and water. • Sand by hand with ultrafine sandpaper. Use rubbing compound if necessary, and polish by machine or manually: • If residue was removed with soap and water, polishing is usually necessary to restore the surface appearance. • If sanding was necessary, surface usually needs rubbing compound and polish.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could provide lessons related to grades of rubbing compounds and polishes and their ingredients, and how friction is used to remove residue.

Review:

Ask students review questions such as the following:

1. What could cause swirl marks?
2. What could cause wheel burns?

Application:

1. Provide students with refinished panels, and ask them to machine rub and polish them, and then check for swirl marks and wheel burns
2. When imperfections are discovered, ask students to stop and identify their cause(s).
3. When students have correctly identified the cause(s) of the imperfections, ask them to correct the problem and finish the machine rubbing and polishing.

Evaluation:

√ The student will identify and correct buffing-related imperfections. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.5.27.

Competency 5.5.27: Identify buffing-related imperfections (swirl marks, wheel burns); correct the condition

Performance Checklist

In identifying and correcting buffing-related imperfections, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Identified all swirl marks and wheel burns on surface	☐	☐	☐	☐	☐
4. Accurately determined cause(s) of the imperfections	☐	☐	☐	☐	☐
5. Corrected the cause(s) of the imperfections	☐	☐	☐	☐	☐
6. Removed swirl marks by repolishing in accordance with standard practice	☐	☐	☐	☐	☐
7. Selected appropriate procedure for removing wheel burns (washing or sanding)	☐	☐	☐	☐	☐
8. Removed wheel burn in accordance with standard practice	☐	☐	☐	☐	☐
9. Used rubbing compound if necessary	☐	☐	☐	☐	☐
10. Polished by hand or machine	☐	☐	☐	☐	☐
11. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 5.5.29: Measure mil thickness

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Measure mil thickness
Criteria:	In accordance with the criteria in the checklist for Competency 5.5.29

Introduction:

General Introductory Techniques: Share personal experiences you have had when measuring mil thickness in the collision repair facility. Show videos that demonstrate measuring techniques.

Competency-Specific Information:

1. Display pictures illustrating excessive film build and insufficient film build (i.e., crazing and cracking).
2. Display gauges used in measuring mil thickness. The topcoat on most new vehicles is 0.075mm–0.120mm thick (.003"–.005").

References:

Service manuals; technical service bulletins (TSBs); spray gun troubleshooting chart (available in many major sources such as *MOTOR Auto Body Repair*). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Types of Mil Gauges	2. Two types of mil thickness gauges: • Magnetic—most common; least expensive; can be used on any substrate except aluminum, alloys, fiberglass, and plastic • Electronic—must be used on aluminum, alloys, fiberglass, and plastic Most vehicles have 3–5 mils of paint, including undercoats.
3. Paint Thickness	3. Mil thickness (film build) must be checked to ensure it is within factory guidelines. Improper film build: • Excessive film build—causes cracking and crazing • Insufficient film build—will not prevent damage from environmental hazards (sunlight, acid rain, pollution) Refer to manufacturer's specifications to determine proper mil thickness.

Presentation Outline	Steps to Cover/Key Points to Make
4. Measuring with Magnetic Mil Gauge (Tinsley Gauge)	4. Place gauge on paint. Slowly pull body of gauge until the head of the gauge releases from the paint. Take the reading at the point when the magnet breaks away from the surface. Read the thickness directly from the scale. **Key Point:** Usually this is done twice to ensure that the thickness measure obtained is accurate. Compare results to manufacturer's specifications.
5. Measuring with Electronic Mil Gauge	5. Place the gauge on the paint. Calibrate the gauge. Check readout for mil thickness. **Key Point:** Check mil thickness in several locations of refinished panel or part. Compare results to manufacturer's specifications.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could help students in using gauges to measure mils. The applied science teacher could provide information on the effect of environmental hazards on paint.

Review:

Ask students review questions such as the following:

1. If there is insufficient film build (mil thickness), what could be the result?
2. If there is excessive film build (mil thickness), what could be the result?
3. Describe the types of gauges and the substrate(s) that each should be used for.

Application:

1. Provide students with various panels with different mil thicknesses of paint, and have them measure the thickness of each.
2. Ask students to compare their results. If any measurements vary, have them remeasure to determine which measurement is correct.

Evaluation:

√ The student will measure mil thickness. His/her performance will be evaluated using a copy of the performance checklist for Competency 5.5.29.

Competency 5.5.29: Measure mil thickness

Performance Checklist

In measuring mil thickness, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected appropriate gauge for type of substrate	☐	☐	☐	☐	☐
3. Identified manufacture-specified mil thickness	☐	☐	☐	☐	☐
4. Placed gauge on flat paint surface	☐	☐	☐	☐	☐
5. Obtained accurate gauge reading	☐	☐	☐	☐	☐
6. Repeated measurement process to ensure accuracy	☐	☐	☐	☐	☐
7. Compared measurements obtained to manufacturer's specifications	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Unit 5: Painting and Refinishing

Subunit 5.6: Final Detail

Competency 5.6.2:	Buff and polish finish as required
Competency 5.6.3:	Clean interior, exterior, and glass
Competency 5.6.4:	Clean body openings (door jambs, edges, etc.)
Competency 5.6.5:	Remove overspray

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform final detailing
Criteria:	In accordance with the criteria in the checklist for Competencies 5.6.2–5.6.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when performing final detailing in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Final detailing of a vehicle provides the selling point for the work you have performed. Even if the repairs and/or refinishing are of superior quality, the work will ***look*** inferior if the car has not been cleaned and detailed before returning it to the customer.

2. Rule of thumb for sequence of detailing work: Interior first, then exterior, and glass last.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Buffing and Polishing Vehicle	2. Conduct a visual inspection to determine whether vehicle needs to be buffed and then polished to return it to preaccident condition. Buffing technique: • Select the type of rubbing compound (coarse, fine, or microfinishing) to be used. General rule of thumb: • If there is little to no shine, a coarse rubbing compound is required. • If it is a newer vehicle, microfinishing compound is usually required. • Apply a small amount of rubbing compound on vehicle. **Key Point:** Only work an area 3' x 3' at a time. • Use a buffer to rub until a uniform, glossy appearance is achieved. Polishing technique: • Apply polish using a clean polishing pad. • Polish until swirl marks from buffing are removed and desired gloss is achieved.

Presentation Outline	Steps to Cover/Key Points to Make
3. Cleaning Vehicle Interior	3. Vacuum vehicle interior. Empty ashtrays. Clean upholstery, leather, and carpets using cleaner appropriate for material. Apply vinyl protection if necessary. **Key Point:** Do not apply vinyl protection to gearshift knobs, steering wheels, or pedals (gas, brake, clutch). **Key Point:** Never use deodorizers as some people may be allergic to them.
4. Cleaning Vehicle Exterior (Including All Body Openings)	4. Wash exterior with soap and water. **Key Point:** Do not use dishwashing liquid as a soap because it will strip the wax off the vehicle. Rinse thoroughly. Dry with chamois or clean cotton towels. **Key Point:** Be sure to clean all door jambs, grills, license plates, mirrors, wheels, etc.
5. Cleaning Vehicle Glass	5. Clean glass—both inside and out—using glass cleaner and paper towels. Be sure to check for streaks.
6. Removing Overspray	6. Overspray on chrome or glass: • Remove by rubbing with steel wool. Overspray on painted surface: • May be necessary to sand or buff or polish to remove.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher can cover the makeup of sandpaper and the role of friction and heat in compounding (sanding at high speed while increasing shine).

Review:

Ask students review questions such as the following:

1. Why is it important to detail a vehicle before returning it to the customer?
2. Should a dishwashing detergent be used to clean a vehicle? Why or why not?
3. How can overspray be removed from a painted surface?

Application:

1. Have students develop a procedure sheet for detailing components (exterior, interior, buff and polish) that can be used to guide student practice in the shop.
2. As students practice interior detailing, quiz them individually on the process (e.g., ask them to describe how they selected the appropriate cleaner(s) to use).
3. As students practice exterior detailing, quiz them individually on the process (e.g., ask them to demonstrate the drying procedure they are using).

Evaluation:

√ The student will perform final detailing. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.6.2–5.6.5.

Competency 5.6.2: Buff and polish finish as required
Competency 5.6.3: Clean interior, exterior, and glass
Competency 5.6.4: Clean body openings (door jambs, edges, etc.)
Competency 5.6.5: Remove overspray

Performance Checklist

In performing final detailing, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Correctly determined whether buffing and polishing were required	☐	☐	☐	☐	☐
4. Completed each of the following detailing steps in accordance with industry procedure and standards:					
a. Buffed vehicle	☐	☐	☐	☐	☐
b. Polished vehicle	☐	☐	☐	☐	☐
c. Vacuumed interior	☐	☐	☐	☐	☐
d. Emptied ashtrays	☐	☐	☐	☐	☐
e. Cleaned upholstery, leather, carpet	☐	☐	☐	☐	☐
f. Applied vinyl protection if necessary	☐	☐	☐	☐	☐
g. Washed exterior and all body openings	☐	☐	☐	☐	☐
h. Rinsed exterior and all body openings	☐	☐	☐	☐	☐
i. Dried exterior and all body openings	☐	☐	☐	☐	☐
j. Cleaned glass both inside and out	☐	☐	☐	☐	☐
k. Removed overspray	☐	☐	☐	☐	☐
5. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 5: Painting and Refinishing
Subunit 5.1: Safety Precautions

Unit 6: Basic Shop and Safety Practices

Competency 5.1.4:	Select and use the NIOSH-approved personal sanding respirator; inspect condition and ensure fit and operation; perform proper maintenance in accordance with industry/manufacturer's specifications
Competency 5.1.5:	Select and use the NIOSH-approved (Fresh Air Make-up System) personal painting/refinishing respirator system
Competency 5.1.6:	Select and use the proper personal safety equipment for painting/refinishing and sanding (gloves, suits, hoods, eye and ear protection, etc.)
Competency 6.1:	Utilize personal safety equipment

Competency Development Guide

Objective:

Condition: As part of all activities in the collision repair facility

Behavior: Utilize personal safety apparel and equipment

Criteria: In accordance with the criteria in the checklist for Competencies 5.1.4/5.1.5/5.1.6/6.1

Introduction:

General Introductory Techniques: Share personal experiences you have had concerning the use of personal safety apparel and equipment in the collision repair facility. Show videos that show various types of equipment and their use.

Competency-Specific Information:

1. Take an inventory. Have everyone count all their fingers, toes, and any other body parts that they have.
2. Announce that at the end of the year, this inventory will be repeated, and students are expected to come up with the same counts.
3. Explain to students that following all the rules for the use of personal safety equipment will help ensure that nothing will be missing in the end-of-the-year body parts inventory.

References:

OSHA 1920.130 series of Personal Protective Standards. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Eye and Ear Protection	1. Wear eye and ear protection in accordance with Occupational Safety and Health Administration (OSHA) standards. Wearing of safety glasses in vocational labs is also required by Ohio state law. Student's responsibility for securing safety glasses
2. Foot and Hand Protection	2. Wear prescribed foot and hand protection. Wearing leather boots with nonskid soles and steel toes is optional. Protective gloves must be worn for working with solvents and welding.
3. Respiratory Protection	3. Select appropriate type of respirator for operation being performed: • Dust or particle respirator: ~ Do not use for vapors or mist. • Cartridge filter respirator: ~ Use when spraying non-activated, isocyanate-free refinishing materials. ~ Perform a positive and negative pressure test fit. ~ Change filters in accordance with manufacturer's specifications. • Air-supplied respirator (hooded or face mask type): ~ Use for two-component materials or for materials that contain isocyanates. ~ For air-supplied respirators that use an oil-less pump to supply air, change filter in accordance with manufacturer's specifications

Presentation Outline	Steps to Cover/Key Points to Make
	Use and maintain all respiratory protection equipment (respirator, spray mask, and mask filters) in accordance with manufacturer's specifications. Use NIOSH-approved respirators. (NIOSH = National Institute for Occupational Safety and Health) **Key Point:** Facial hair may interfere with fit of particle mask and half-mask respirators.
4. Clothing/Paintsuits	4. Wear clothes that do not interfere with running machinery and in accordance with shop policy. Paintsuits should be worn in accordance with manufacturer's specifications and/or OSHA guidelines. **Key Point:** A paintsuit must be worn when using two-component or isocyanate products.
5. Jewelry	5. Remove jewelry in accordance with shop policy. Remember that a dangling earring or chain can get caught in moving machinery and cause serious injury.
6. Hair	6. Secure long hair (e.g., wear a cap or tie hair back) according to shop policy.
7. Lifting Techniques	7. Bend knees, not back. Get assistance for heavy loads. Use caution when twisting and lifting.
8. Maintaining Personal Protective Equipment	8. Clean protective equipment prior to and after each use. Store protective equipment after each use so that it is not damaged.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can work with students in reading and interpreting OSHA standards. The applied science teacher could cover how to read an MSDS and the effects of different levels of exposure on humans.

Review:

Ask students review questions such as the following:

1. When should safety glasses be worn in the shop?
2. Why is respiratory protection so critical to the safety and long-term health of auto collision technicians?
3. How should you lift heavy objects?
4. List some reasons why jewelry should be removed.
5. Identify three ways long hair could be shortened in a "shop experience."

Application:

1. Have students work in teams to develop safety posters, fliers, handbooks, etc., covering the use of personal safety equipment in the shop.
2. Ask students to perform an instructor- or school-prepared safety inspection of the entire automotive laboratory. (This should be done at ***least*** monthly and at random times.)

Evaluation:

√ Each student will utilize personal safety apparel and equipment. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.1.4/ 5.1.5/5.1.6/ 6.1.

Competency 5.1.4:	Select and use the NIOSH-approved personal sanding respirator; inspect condition and ensure fit and operation; perform proper maintenance in accordance with industry/manufacturer's specifications
Competency 5.1.5:	Select and use the NIOSH-approved (Fresh Air Make-up System) personal painting/refinishing respirator system
Competency 5.1.6:	Select and use the proper personal safety equipment for painting/refinishing and sanding (gloves, suits, hoods, eye and ear protection, etc.)
Competency 6.1:	Utilize personal safety equipment

Performance Checklist

In utilizing personal safety apparel and equipment, the student—

	1	2	3	4	5
1. Selected/used correct equipment	☐	☐	☐	☐	☐
2. Wore eye and ear protection in accordance with OSHA standards	☐	☐	☐	☐	☐
3. Wore prescribed foot and hand protection	☐	☐	☐	☐	☐
4. Wore respiratory protection in accordance with manufacturer's specifications	☐	☐	☐	☐	☐
5. Wore clothing in accordance with OSHA standards and manufacturer's specifications	☐	☐	☐	☐	☐
6. Removed jewelry in accordance with shop policy	☐	☐	☐	☐	☐
7. Secured long hair	☐	☐	☐	☐	☐
8. Practiced established lifting techniques	☐	☐	☐	☐	☐
9. Maintained personal protective equipment	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 6.2: Respond to fire situations

Competency Development Guide

Objective:

Condition:	Given a series of written case studies and simulated situations
Behavior:	Demonstrate knowledge of how to respond to fire situations *
Criteria:	In accordance with the criteria in the checklist for Competency 6.2

Introduction:

General Introductory Techniques: Share personal experiences you have had with fire situations in the collision repair facility. Show videos that show fire situations, types of fires, proper responses, and/or use of fire extinguishers.

Competency-Specific Information:

1. In an emergency situation, action needs to be taken quickly. An emergency situation is not the time to develop such a plan.
2. Auto shops may have occasional fires, and part of your training is how to respond to a fire situation.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

* If local conditions allow, students may be able to witness (or even demonstrate actual responses to) fire situations. Check with local fire department or local fire training programs, and see if you can set up fire demonstrations. Make sure you check with the administration concerning insurance issues related to fire demonstrations.

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Fire Exits and Alarms	1. Locate all fire exits and alarms. Never place equipment in front of alarms and exits.
2. Evacuation Procedures	2. Importance of identifying established evacuation procedures for each facility in which you work Evacuation procedure for classroom/ shop Evacuation practice (drills) in accordance with specified procedure
3. Fire Blankets and First Aid Kits	3. Locate fire blankets and first aid kits. Ensure that first aid kit is kept fully stocked.
4. Fire Triangle	4. Three elements that must be present for a fire to occur: • Oxygen • Fuel • Heat
5. Types of Fires	5. Types of fires (e.g., chart/list of fire classifications available in textbook or through local fire department) Most common types of fires in collision repair and refinish setting involve ignition of volatile materials through use of heat- and spark-producing equipment (e.g., stud guns, welders).

Presentation Outline	Steps to Cover/Key Points to Make
6. Handling of Volatile Materials	6. Types of volatile materials: • Paints • Primers • Paint thinners • Body fillers • Reducers • Paint additives • Spray adhesives Volatile materials are unstable and will ignite and burn. They must be routinely kept in approved containers and should be stored in approved safety cabinets or fireproof rooms. Avoid using heat- and spark-producing equipment around these materials.
7. Fire Extinguisher Operation	7. Established procedures for using fire extinguishers ***Note:*** Most extinguishers require that you aim at base of fire.
8. Fire Extinguisher Maintenance	8. Established procedures for maintaining the operability of fire extinguishers Checking inspection stickers
9. Reporting Procedures	9. Follow established site-developed reporting procedures.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied science teacher could explain how a fire "works" and how it is extinguished and the effect of different extinguishers on different types of fires (i.e., why some work and some don't).

Review:

Ask students review questions such as the following:

1. What elements make up the three sides of the fire triangle?
2. What are the different types of fires? Which extinguishing method should you use for each type?
3. Where should you go and how should you act in case of a fire in the classroom or shop?

Application:

1. Give students a teacher-prepared shop diagram, and have them locate the position of all fire alarms, fire exits, fire extinguishers, first aid kits, fire blankets, and fireproof cabinets or rooms.
2. Give students written case studies describing different types of fire situations, and have them select the correct type of extinguisher and correct overall response for each situation.
3. Have students participate in an evacuation drill.
4. Have each student orally explain the correct procedure for using a fire extinguisher.

Evaluation:

√ Each student will demonstrate knowledge of how to respond to fire situations. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.2.

Competency 6.2: Respond to fire situations

Performance Checklist

In demonstrating knowledge of how to respond to fire situations, the student—

	1	2	3	4	5
1. Identified correct equipment for case situation	☐	☐	☐	☐	☐
2. Identified location of all fire exits and alarms	☐	☐	☐	☐	☐
3. Followed established evacuation procedures	☐	☐	☐	☐	☐
4. Identified location of fire blankets and first-aid kits	☐	☐	☐	☐	☐
5. Identified volatile materials and fireproof storage available	☐	☐	☐	☐	☐
6. Identified types of fires	☐	☐	☐	☐	☐
7. Explained how to use fire extinguishers in accordance with established procedures	☐	☐	☐	☐	☐
8. Verified operability of fire extinguishers	☐	☐	☐	☐	☐
9. Explained established reporting procedures	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**______________

Competency 6.3:	Demonstrate general safety practices

Competency Development Guide

Objective:

Condition:	As part of all activities in the collision repair facility
Behavior:	Demonstrate general safety practices
Criteria:	In accordance with the criteria in the checklist for Competency 6.3

Introduction:

General Introductory Techniques: Share personal experiences you have had related to general safety practices in the collision repair facility. Show videos that illustrate these practices.

Competency-Specific Information:

1. Introduce topic of safety through discussion of questions such as the following:
   - Who is responsible for your safety?
   - How can doing a job safely affect your company's profit?
   - How can ***not*** following safety rules affect those around you?

References:

OSHA Form 200 for reporting injuries and supplemental 101; OSHA "Job Hazard Analysis," Pamphlet 3071, 1988; OSHA "Lockout/Tagout Standard" (19 CFR 1910.47); and "Lifting It Right: A Safety Video for Automotive Lifts," Automotive Lift Institute. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling***. However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Shop Safety Practice Guidelines	1. Shop safety policies and procedures Importance of accepting responsibility for complying with shop safety plan Consequences of failure to comply with shop safety plan (physical and property damage that may occur)
2. Emergencies and Injuries	2. Facility emergency preparedness plan Facility requirements for responding to emergencies and injuries Procedure for reporting injuries to supervisor Procedure for completing written safety and injury reports: • Use of OSHA Form 200 and supplemental 101 Forms • Use of site-developed injury report
3. Jacking, Lifting, Moving, and Blocking Vehicles	3. Established procedures for jacking, lifting, moving, and blocking vehicles: • Industry-developed standard "Lift it Right" • Site-developed procedures Importance of checking brakes before moving vehicles Consequences of failure to check brakes Safe driving practices according to shop procedures; for example: • Go very slowly. • Make sure no one is standing behind or in front of vehicle. • Check that the brake pedal is not going to floor. • Don't drive over or on spilled liquids. Driver's license requirements Insurance requirements

Presentation Outline	Steps to Cover/Key Points to Make
4. Chains and Straps	4. Established procedures for using chains and straps; for example: • Never use damaged chains/straps. • Never stand in path or travel of chain or strap.
5. Hand Tools	5. Procedure for maintaining hand tools in safe operating condition Instances of dangerous hand tools; for example: • Mushroomed chisels • Greasy hammers • Tools without handles or with loose handles • Tools used for a purpose for which they were not designed
6. Shop Equipment	6. Equipment safety checks: • Guards • Shields • Frayed electrical cords • Bypassed switches
7. Defective Equipment	7. Lock-out/tag-out procedures for defective equipment: • OSHA "Lockout/Tagout Standard" (19 CFR 1910.47) • Site-developed guidelines
8. Working Conditions	8. Importance of concern for the safety of others and need to screen off work area to protect others from danger (e.g., equipment that throws sparks, flash burns from welding/cutting operations) Offenses that could result in unsafe working conditions leading to disciplinary actions (e.g., horseplay, substance abuse, theft) Site-developed consequences for the offenses

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on reading and interpreting established safety standards.

Review:

Ask students review questions such as the following:

1. List some consequences of not following safety instructions.
2. What are the rules for moving vehicles in the shop?
3. What are offenses that could get you in trouble, and what are the consequences of those offenses?
4. From what types of dangers would you need to protect others in the shop, and how should you protect them?

Application:

1. Have students practice skills in jacking, lifting, moving, and blocking vehicles.
2. Have students practice maintaining their own or assigned set of hand tools.
3. Describe an injury situation to students, and have them complete an injury report.
4. Give students written case studies describing injuries suffered by the instructor and other individual students, and ask them to explain what steps to take and procedures to follow in dealing with each injury.
5. Have students practice basic first aid.

Evaluation:

√ Each student will demonstrate general safety practices. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.3.

Competency 6.3: Demonstrate general safety practices

Performance Checklist

In demonstrating general safety practices, the student—

	1	2	3	4	5
1. Selected correct equipment to use	☐	☐	☐	☐	☐
2. Interpreted shop policy and procedures accurately	☐	☐	☐	☐	☐
3. Complied with shop safety plan	☐	☐	☐	☐	☐
4. Responded to emergencies and injuries in accordance with facility requirements	☐	☐	☐	☐	☐
5. Reported injuries to supervisor in accordance with established shop procedure	☐	☐	☐	☐	☐
6. Completed written safety and injury reports fully and correctly, using appropriate form or format	☐	☐	☐	☐	☐
7. Carried out all jacking, lifting, moving, and blocking of vehicles and shop equipment in accordance with established policies and procedures	☐	☐	☐	☐	☐
8. Checked brakes before moving vehicular equipment	☐	☐	☐	☐	☐
9. Demonstrated safe driving practices (following school policies)	☐	☐	☐	☐	☐
10. Used chains and straps in a safe manner	☐	☐	☐	☐	☐
11. Maintained hand tools in safe operating condition	☐	☐	☐	☐	☐
12. Maintained shop equipment in safe operating condition in accordance with manufacturers'/OSHA specifications	☐	☐	☐	☐	☐
13. Complied with lock-out/tag-out procedures for defective equipment	☐	☐	☐	☐	☐
14. Ensured the safety of others in the work area	☐	☐	☐	☐	☐
15. Avoided offenses that could result in disciplinary action	☐	☐	☐	☐	☐
16. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**_______________

Unit 5: Painting and Refinishing
Subunit 5.1: Safety Precautions

Unit 6: Basic Shop and Safety Practices

Competency 5.1.1:	Identify and take necessary precautions with hazardous operations and materials according to federal, state, and local regulations
Competency 5.1.2:	Identify personal health and safety hazards according to OSHA guidelines and "Right to Know" Act
Competency 6.4:	Maintain safe work environment

Competency Development Guide

Objective:

Condition:	As part of all activities in the collision repair facility
Behavior:	Maintain a safe work environment
Criteria:	In accordance with the criteria in the checklist for Competencies 5.1.1/5.1.2/6.4

Introduction:

General Introductory Techniques: Share personal experiences you have related to the safety of the work environment. Show videos that demonstrate how to maintain a safe work environment and/or consequences of an unsafe environment.

Competency-Specific Information:

1. 1994 OSHA Standard (29 CFR 1910, 1200) covers material safety data sheets (MSDSs) and employee's right to know.

2. Having a well-organized, clean, well-maintained, and well-lit shop is one good way to maintain a safe work environment.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Shop Cleanliness	1. Importance of maintaining clean work environment How to clean shop
2. Air Filtering and Ventilation	2. General guidelines: • An exhaust fan that will promote air circulation is required by some states. • Dust collectors should be used daily to remove dust and air-borne particles; clean and change filters per manufacturer's recommendations. • Paint booth filters should be changed per manufacturer's recommendations.
3. Air Pressure Regulation	3. There are regulators throughout shop where air lines come in. The pressure of the air in those lines is 175 psi. Most *pneumatic* (air-powered) equipment uses 30–120 psi (e.g., sanders, drills, grinders, spray guns). Manufacturer's specifications will identify the appropriate psi range for each piece of equipment. To regulate the pressure, you turn the knob provided until the needle gauge shows the recommended range. When the psi range is correct, the equipment operates most efficiently. If the psi is too high, it can damage the equipment and produce a noise level higher than OSHA safety standards allow.

Presentation Outline	Steps to Cover/Key Points to Make
4. Sources of Contamination and Other Hazards (Identification/Containment)	4. Acute contamination Chronic contamination Air-borne contamination Other hazards (e.g., asbestos) Shop rags used to clean parts
5. Draining, Removal, and Storage of Gasoline Tanks	5. Established safety procedures (check with local fire department) Why a nearly empty tank may be more dangerous than a full one
6. Handling of Flammable Liquids	6. Established safety rules (6.2)
7. Labeling of Containers	7. Most often-used products are purchased in large containers (e.g., 5 gallons, 15 gallons, 55 gallons). The containers must be stored away from the main building, and OSHA specifies how much of the product can be brought into the facility at one time (e.g., 5 gallons). For safety, the new (smaller) container must be fireproof (usually color-coded) and clearly labeled. Labeling ensures that users and fire officials can tell exactly what the container holds. It protects humans from danger and vehicles from damage.
8. Storage, Use, Recycling, and Disposal of Hazardous Materials	8. Follow EPA regulations. Check with local fire department, which may have additional regulations. Analyze liability associated with hazardous material disposal. Responsibility does not end when the hazardous material leaves the site.

Presentation Outline	Steps to Cover/Key Points to Make
9. Hazardous Chemical Spills	9. Ohio ranks third in chemical accidents in the nation. Procedure for responding to hazardous chemical spills, including— • Keep material away from the drains. • If unsure, stay away. • Report per EPA guidelines. • Report to fire department if necessary.
10. Unsafe Practices and Conditions	10. Report unsafe practices and conditions. The instructor needs the eyes, ears, and noses of everyone in the shop. Correct unsafe practices and conditions. Don't leave spilled products on the floor. Person responsible for spill should clean it.
11. OSHA Right-to-Know Laws	11. Consumers have a right to information about— • product ingredients, when those ingredients are not a trade secret; and • any hazards, whether they are a trade secret or not. Hazard Communication Standard
12. Material Safety Data Sheets (MSDSs)	12. MSDSs identify the following: • Possible hazards when using the materials • Protective measures to take when using the materials • What to do if exposed to a material

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could work with students on documenting storage of hazardous materials and reading and interpreting MSDSs. The applied science teacher could discuss environmental and physical safety concerns associated with working with hazardous materials.

Review:

Ask students review questions such as the following:

1. What is the pressure of the air coming into the shop through the air station outlets, and how do you determine what psi setting to use for a particular piece of equipment?
2. What is the difference between acute and chronic?
3. Do you have the right to know about hazardous materials if they are a trade secret? Explain your answer.
4. What is the best way to handle an oil spill?
5. When does responsibility end for a hazardous waste?

Application:

1. Give students a sample MSDS, and have them identify the hazards related to the chemical, protective measures to take when using it, and consequences of exposure to the chemical.
2. Give students written case studies describing situations involving different chemical spills, and have them explain how to respond to each in accordance with shop policy.
3. As students practice cleaning up spills, quiz them individually on the process (e.g., ask them how to select the appropriate cleaning supplies to use).

Evaluation:

√ Each student will maintain a safe work environment. His/her performance will be evaluated using a copy of the performance checklist for Competencies 5.1.1/5.1.2/6.4.

Competency 5.1.1:	Identify and take necessary precautions with hazardous operations and materials according to federal, state, and local regulations
Competency 5.1.2:	Identify personal health and safety hazards according to OSHA guidelines and "Right to Know" Act
Competency 6.4:	Maintain safe work environment

Performance Checklist

In maintaining a safe work environment, the student—

	1	2	3	4	5
1. Selected correct equipment and supplies to use	☐	☐	☐	☐	☐
2. Followed TSB safety recommendations	☐	☐	☐	☐	☐
3. Maintained clean work environment	☐	☐	☐	☐	☐
4. Followed EPA regulations for air filtering and ventilation of the work environment	☐	☐	☐	☐	☐
5. Regulated air pressure to equipment manufacturer's specifications	☐	☐	☐	☐	☐
6. Identified sources of contamination and other hazards	☐	☐	☐	☐	☐
7. Contained sources of air-borne contamination and other hazards (e.g., asbestos)	☐	☐	☐	☐	☐
8. Followed established safety procedures for the draining, removal, and storage of gasoline tanks	☐	☐	☐	☐	☐
9. Followed safety rules for handling flammable liquids	☐	☐	☐	☐	☐
10. Labeled containers according to OSHA regulations	☐	☐	☐	☐	☐
11. Followed EPA regulations for the storage, use, recycling, and disposal of hazardous materials	☐	☐	☐	☐	☐
12. Analyzed the liability associated with hazardous material disposal	☐	☐	☐	☐	☐
13. Responded to hazardous chemical spills	☐	☐	☐	☐	☐
14. Reported unsafe practices and conditions	☐	☐	☐	☐	☐
15. Corrected unsafe practices and conditions	☐	☐	☐	☐	☐
16. Interpreted OSHA Right-to-Know law	☐	☐	☐	☐	☐
17. Interpreted material safety data sheets (MSDSs)	☐	☐	☐	☐	☐
18. Identified resources for employee's rights to information	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 6.5:	Access needed information using available references and resources

Competency Development Guide

Objective:

Condition:	Provided with service references and resources
Behavior:	Access needed information
Criteria:	In accordance with the criteria in the checklist for Competency 6.5

Introduction:

General Introductory Techniques: Share personal experiences you have had when accessing needed information in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. You can't work on today's vehicles without access to additional technical information. Your brain can't hold all the information you need.
2. In fact, you may find that the most common tool you use, after your brain, is some kind of service information tool—be it a manual or a computer.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Identifying Available Resources	1. Types and examples of each: • Manufacturer's specifications • Videos • Computer manuals • Service bulletins • Service manuals • Parts manuals • Company procedure manuals • Manufacturers' toll-free numbers • Internet sites • Estimating guides
2. Selecting Appropriate Resource for Given Task	2. When, where, and how each type of resource is used
3. Locating Information Within Resource	3. How to find needed service information
4. Interpreting Information	4. How to read charts, graphs, schematics, illustrations, and tables

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher could help students in locating and interpreting information and with their oral communication skills. The applied mathematics teacher could work with students on reading and interpreting graphs, charts, tables, etc.

Review:

Ask students review questions such as the following:

1. Name five different types of service information sources and how they are used.
2. What type of resource would you use to determine how to remove a door interior panel?
3. What is the difference between a service bulletin and a service manual?

Application:

1. Give students a wiring diagram, and have them locate circuit numbers, wire colors, and possible problems in a circuit.
2. Give students access to technical service manuals, and have them locate the information necessary to replace a particular part (e.g., electric window motor) on a given vehicle.
3. Give students a chart and a particular symptom (e.g., inoperable windshield wipers), and have them use the chart to diagnose where the problem could be.
4. Have students locate five sites on the Internet that contain service information.

Evaluation:

√ Each student will access needed information. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.5.

Competency 6.5: Access needed information using available references and resources

Performance Checklist

In accessing needed information, the student—

	1	2	3	4	5
1. Identified available resources	☐	☐	☐	☐	☐
2. Selected appropriate reference materials and resources for each given task	☐	☐	☐	☐	☐
3. Located needed information within each given reference or resource	☐	☐	☐	☐	☐
4. Correctly interpreted text material	☐	☐	☐	☐	☐
5. Correctly interpreted materials provided in chart form	☐	☐	☐	☐	☐
6. Correctly interpreted materials provided in graph form	☐	☐	☐	☐	☐
7. Correctly interpreted materials provided in table form	☐	☐	☐	☐	☐
8. Correctly interpreted materials provided in illustrations	☐	☐	☐	☐	☐
9. Correctly interpreted materials provided in schematics	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________________**Date**______________

Competency 6.6: Use basic measuring tools

Competency Development Guide

Objective:

Condition: Provided with a set of basic measuring tools
Behavior: Demonstrate use of basic measuring tools
Criteria: In accordance with the criteria in the checklist for Competency 6.6

Introduction:

General Introductory Techniques: Share personal experiences you have had when using basic measuring tools in the collision repair facility. Show videos that show basic measuring tools and their uses.

Competency-Specific Information:

1. Basic measuring tools are used in many tasks in the auto collision repair & refinish industry. Knowing what tool and procedure to use is critical to being successful in the industry. As professional auto collision technicians, poor habits concerning the care and use of measuring tools will cost you in safety, in productivity, and in dollars. Ask yourselves, is it worth doing it correctly?
2. In this lesson (or lessons), you will get a general overview of the types of measuring tools used by auto collision technicians, their names, and their characteristics. Then, throughout the program, we will spend more time on the correct and safe use and proper care of measuring tools as they are used in performing specific tasks.
3. ***And remember,*** an essential prerequisite to being able to obtain accurate measurements is the ability to perform the following functions for whole numbers, fractions, and decimals: addition, subtraction, multiplication, and division.

References:

Tool lists in the NATEF document, *ASE Program Certification Standards for Collision Repair & Refinish Technician Training Programs*. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Applicable Safe Practices	1. Follow standard safe practices (e.g., use of safety glasses; proper footwear; hair restrained; no loose clothing or jewelry).
2. Measuring Tools and Their Uses	2. Examples of gauges used in the auto collision & repair industry: • Self-centering and tram gauges—used for straightening frames • Torque wrench—used in torquing fasteners • Tire pressure gauge—used to measure amount of air pressure in tires • Film thickness gauge—used for measuring thickness of paint on vehicle • Digital multimeter (DMM)—also called digital volt ohmmeter (DVOM)—used in measuring voltage, amperage, and resistance • Cooling system pressure tester—used for measuring pounds per square inch (psi) of pressure • Wheel alignment gauge—used for measuring caster and camber **Key Point:** Gauges can be read in incremental units or digitally. Examples of other measuring tools used in the auto collision & repair industry: • Tape measure—used to measure such things as size of panels and other materials or inside and outside diameter • Paint sticks and measuring cups—used to measure and mix paint
3. Selecting Appropriate Measuring Tool for Given Task	3. When, where, and how to use each tool

Presentation Outline	Steps to Cover/Key Points to Make
4. Measurements (English & Metric)	4. How to measure each of the following using a gauge: • Pressure (e.g., air pressure in tires, cooling system pressure, torque) • Frames and frame dimensions (tram, wheel alignment) • Paint thickness • Voltage, amperage, and resistance How to measure each of the following using other measuring tools: • Length • Volume • Inside/outside diameter of hoses

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher can help with basic math functions and measurements (metric and English).

Review:

Ask students review questions such as the following:

1. What is the difference between the metric system and the English system of measurement?
2. Why is it so important to measure accurately?
3. How do you know what measuring tool to use?

Application:

1. Give students various items (e.g., hoses, panels, fenders), and have them measure each.
2. Provide students with a vehicle, and ask them to measure its wheel base.
3. Have students measure and compare the inside and outside diameter of various hoses.
4. Ask students to adjust tire air pressure in accordance with manufacturer's specifications.

Evaluation:

√ Each student will demonstrate use of basic measuring tools. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.6.

Competency 6.6: Use basic measuring tools

Performance Checklist

In demonstrating use of basic measuring tools, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Performed basic math functions accurately, including—					
a. Addition of whole numbers, fractions, and decimals	☐	☐	☐	☐	☐
b. Subtraction of whole numbers, fractions, and decimals	☐	☐	☐	☐	☐
c. Multiplication of whole numbers, fractions, and decimals	☐	☐	☐	☐	☐
d. Division of whole numbers, fractions, and decimals	☐	☐	☐	☐	☐
3. Demonstrated knowledge of measuring tools and their uses	☐	☐	☐	☐	☐
4. Selected tool appropriate for each given task	☐	☐	☐	☐	☐
5. Applied metric and English measurement skills	☐	☐	☐	☐	☐
6. Obtained accurate readings using a digital multimeter	☐	☐	☐	☐	☐
7. Obtained accurate measurements in measuring each of the following:					
a. Length	☐	☐	☐	☐	☐
b. Pressure	☐	☐	☐	☐	☐
c. Volume	☐	☐	☐	☐	☐
8. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 6.7: Perform basic mechanical skills

Competency Development Guide

Objective:

Condition:	Provided with the necessary tools and materials, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Perform basic mechanical skills
Criteria:	In accordance with the criteria in the checklist for Competency 6.7

Introduction:

General Introductory Techniques: Share personal experiences you have had when using performing basic mechanical skills in the collision repair facility. Show videos that show the steps in performing each skill.

Competency-Specific Information:

1. Performance of basic mechanical skills is a learned art form.

2. In this lesson (or lessons), you will get a general overview of the procedures for performing these basic mechanical skills. Then, throughout the program, we will spend more time on these skills as they are used in performing specific collision repair tasks.

References:

Tool lists in the NATEF document, *ASE Program Certification Standards for Collision Repair & Refinish Technician Training Programs*. (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Applicable Safe Practices	1. Follow standard safe practices (e.g., use of safety glasses; proper footwear; hair restrained; no loose clothing or jewelry).
2. Tap and Die Techniques & Repairing Damaged Threads	2. Tap—used to cut new threads or repair damaged threads in an existing drilled hole General guidelines for using tap: • Select correct tap for hole size. • Insert tap into hole, and turn clockwise to make new threads. Die—used to cut threads or repair damaged threads on a bolt or rod General guidelines for using die: • Select correct die size. • Insert bolt into die, and turn clockwise to thread. **Key Point:** When selecting a tap or die, duplicate original thread and pitch if possible.
3. Drilling Holes	3. Select drill bit size for desired diameter of hole. Drill hole according to standard procedure. **Key Point:** Hold drill straight and level.
4. Sharpening Drill Bits and Chisels	4. Use a hard wheel bench grinder to— • sharpen chisels to desired edge or point; and/or • sharpen drill bits to proper angle. Use drill gauge to check angle.

Presentation Outline	Steps to Cover/Key Points to Make
5. Extracting Broken Screws	5. Standard procedures for extracting broken screws using two common methods: • Use a tool called an Easyout. • Using a left-handed drill bit, put drill in reverse, and back screw out of hole.
6. Assembling Hydraulic/Pneumatic Hose and Tubing	6. Hydraulic hoses are sent to an outside company for assembly. Pneumatic hoses can be made or repaired using the following process: • Cut hose. • Place ring around outside of hose. • Install fitting inside hose. • Crimp.
7. Flaring Techniques (Single and Double)	7. Flaring techniques are used on fuel lines, air conditioning lines, and brake lines. Standard procedure for flaring, including how to— • cut hose cleanly; • use flaring tool safely; and • determine whether a single or double flare is needed. **Key Point:** All brake lines must be double-flared.
8. Soldering Techniques	8. Soldering—used to connect two wires or install a wire connector A flame or flameless soldering gun can be used. Standard procedure for soldering, including— • heating the wire until solder melts; and • using a non-acid core solder to prevent corrosion over time.

Presentation Outline	Steps to Cover/Key Points to Make
9. Wire Connection Techniques: Soldering, Crimping, Insulating	9. Standard techniques: • Soldering—see Step 8 • Crimping—use wire crimpers according to the gauge of the wire. • Insulating—use *heat shrink*, a sleeve that, when heated, shrinks and connects the wire. • Electrical tape—wrap wire connection.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could cover proper angle or pitch related to grinding and accurately measuring hose lengths. The applied science teacher could deal with soldering principles and properties of electrical tape.

Review:

Ask students review questions such as the following:

1. How do you determine which basic mechanical procedure to use?
2. What is the difference between tap and die techniques?
3. What is the difference between a single and double flare?

Application:

1. Give students wire and wire connections, and, have them practice connecting wires using soldering, crimping, and insulating techniques.
2. Give students a piece of metal, and have them drill three different sizes of holes and tap each hole.
3. Give students a piece of metal containing broken screws, and have them extract the screws using both extraction techniques and repair the damaged threads.

Evaluation:

√ Each student will perform basic mechanical skills. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.7.

Competency 6.7: Perform basic mechanical skills

Performance Checklist

In performing basic mechanical skills, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Performed each of the following mechanical skills in accordance with standard procedures and standards:					
a. Drilled holes	☐	☐	☐	☐	☐
b. Used tap and die techniques	☐	☐	☐	☐	☐
c. Sharpened drill bits and chisels	☐	☐	☐	☐	☐
d. Extracted broken screws	☐	☐	☐	☐	☐
e. Repaired damaged threads	☐	☐	☐	☐	☐
f. Performed single and double flaring techniques	☐	☐	☐	☐	☐
g. Assembled pneumatic hose	☐	☐	☐	☐	☐
h. Performed soldering techniques	☐	☐	☐	☐	☐
i. Performed wire connection techniques (soldering, crimping, insulating)	☐	☐	☐	☐	☐
3. Maintained clean work area	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 6.8: Manage customer relations

Competency Development Guide

Objective:

Condition:	As part of all customer-related activities in the collision repair facility
Behavior:	Manage customer relations
Criteria:	In accordance with the criteria in the checklist for Competency 6.8

Introduction:

General Introductory Techniques: Share personal experiences you have had in managing customer relations in the collision repair facility. Show videos that illustrate different situations involving customers and recommended techniques for handling those situations.

Competency-Specific Information:

1. You may think your job involves dealing with vehicles, but dealing with customers can also be critically important.
2. Ask students to suggest some of the possible benefits of good customer relations (e.g., projecting positive company image, being able to secure information that will aid the repair process).

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Greeting Customer	1. Get to new customers as quickly as possible. If customers will need to wait, say so nicely and briefly. Don't just ignore them until you can get to them. Be polite. Have a professional appearance (e.g., reasonably clean uniform and hands). Convey a positive attitude—one that says we can help you and we can do it efficiently. Speak clearly and use correct grammar. Provide sufficient information for customer to understand what you're saying.
2. Listening Actively	2. You can learn a lot from listening. Let customers know you care—that you are focused on their needs. They have a need to explain, and what they say can be very helpful. Your attitude can help you get the job. If you don't seem to care about their problems, they may take their business elsewhere. Keep the explanation on track by asking targeted questions to get the information you need. For example: • Details about the accident • Direction of impact Acknowledge customers' comments and questions with a phrase (e.g., "I see") or a nod so they know you're listening.

Presentation Outline	Steps to Cover/Key Points to Make
	Treat customers with respect. • If a customer thinks he or she knows it all, stay neutral. • If a customer has difficulty explaining because of a lack of knowledge, help him or her with good questions. • Don't feel obliged to point out a customers' ignorance. They won't thank you for it.
3. Being Honest and Forthright	3. Don't make promises you can't keep. Don't exaggerate the amount of time and money required for the repairs. If you cause damage during the repair process— • Accept responsibility for it, and make the additional needed repairs. • Don't claim it was hidden or pre-existing damage or hope the customer doesn't notice. If a customer comes back later with a complaint, deal with it fairly. • Was it hidden damage you didn't catch? • Did you not listen well enough to the customer's first explanation about the problems? • Did something in the repair process cause later damage (e.g., sanding around a window can cause it to crack when driven). Trying to trick the customer may seem like a good idea in the short-term, but it can have long-term negative effects. The tricked customer is unlikely to provide repeat business—and a negative reputation can spread rapidly.

Presentation Outline	Steps to Cover/Key Points to Make
4. Maintaining Self-Control	4. Maintain professionalism when dealing with angry or upset customers. Speak calmly and maintain a neutral attitude. Arguing with or yelling at a customer— • takes time away from the job; • presents a bad image to other customers; and • generally makes the situation worse.
5. Communicating Via Telephone	5. When you answer the phone, do the following: • Identify the company. • Identify yourself. • Ask, "May I help you?" • Sound interested and professional. • Convey that the caller's business is important to you. Know the shop procedure for handling questions. • Technicians can't get anything done if they're constantly being called to the phone. • Need to be able to convince the customers—in a nice way—to let you get an answer and call them back. Know the shop policies concerning what information you can give out (e.g., avoid giving estimates over the phone; it's too easy to be wrong).

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can involve students in various role-playing situations involving communication with customers—explaining procedures, responding to customer complaints, etc.

Review:

Ask students review questions such as the following:

1. Listening to customers can be time-consuming. Why is this time well spent?
2. Why is it important to identify the company and yourself when you answer the phone?

Application:

1. Give students written case studies describing different situations involving communication between technicians and customers, and have them critique each technician's performance: what did he or she do right, what did he or she do wrong, how could he or she have handled the situation better?
2. Have students develop a list of targeted questions they could use in trying to secure needed information from customers.

Evaluation:

√ Each student will manage customer relations. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.8.

Competency 6.8: Manage customer relations

Performance Checklist

In managing customer relations, the student—

	1	2	3	4	5
1. Attended to new customers in a timely manner	☐	☐	☐	☐	☐
2. Was consistently polite and respectful	☐	☐	☐	☐	☐
3. Presented a professional appearance	☐	☐	☐	☐	☐
4. Conveyed a positive attitude	☐	☐	☐	☐	☐
5. Spoke clearly, using correct grammar	☐	☐	☐	☐	☐
6. Provided sufficient information for customer understanding	☐	☐	☐	☐	☐
7. Listened actively to customer	☐	☐	☐	☐	☐
8. Used targeted questions to keep customer's explanation on track	☐	☐	☐	☐	☐
9. Was honest and forthright in all dealings with customers	☐	☐	☐	☐	☐
10. Maintained professionalism and calmness in dealing with angry or upset customers	☐	☐	☐	☐	☐
11. Followed shop procedures and policies in communicating via telephone	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name______________________________**Date**______________

Competency 6.9: Prepare estimates

Competency Development Guide

Objective:

Condition:	Provided with a vehicle or training aid, manufacturer's information, and while following all applicable safety guidelines
Behavior:	Prepare an estimate
Criteria:	In accordance with the criteria in the checklist for Competency 6.9

Introduction:

General Introductory Techniques: Share personal experiences you have had when preparing estimates in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Ask students if they have ever seen an estimate prepared.
2. Explain that estimates can be prepared manually or by computer.
3. All estimates should be neatly and legibly prepared, and all figures should be competitive (comparable to those of other local shops).

References:

Estimating manuals (e.g., Mitchell, Motor). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

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Presentation Outline	Steps to Cover/Key Points to Make
1. Reinforcement of Basic Work Practices	1. General safety (6.1–6.4) Accessing needed information using available references and resources (6.5) Selecting and using basic tools (6.6–6.7) Providing customer service (6.8)
2. Greeting Customer	2. Greet customer politely and secure the following information: • Name, address, and phone number • Make, model, and year of vehicle
3. Conducting Visual Inspection	3. Locate the following information: • Vehicle Identification Number (VIN) • Paint code • Date vehicle was built Start with damage, and use a systematic approach to ensure that all damage is recorded. Look for previous, unrelated damage; and hidden damage. Make list of all damaged parts.
4. Estimating Costs	4. Using an estimating guide, look up vehicle year and model to identify the following: • Cost of replacement parts • Body labor costs • Paint labor costs • Costs of non-included operations Compare body labor costs for **repairing** damage versus **replacing** part, and make judgment call concerning which is most cost-effective.

Presentation Outline	Steps to Cover/Key Points to Make
	Ask customer whether new, used, or aftermarket parts are preferred. **Rule of Thumb:** If vehicle is less than 5 years old, use new parts. If vehicle is more than 5 years old, use aftermarket or used parts. **Key Point:** Determine whether any repairs need to be subcontracted.
5. Preparing Written Estimate	5. Using information gathered above, make a complete itemized list of parts, time, and materials for specific vehicle. Calculate total cost of estimate: Cost of parts, time, materials + Any hazardous materials disposal charge + Tax = Total cost of estimate Sign the estimate (as preparer of estimate). The estimate is now ready to be shared with the customer or insurance company. **Key Point:** Some body shops contact the insurance agent for the customer.
6. Explaining Estimate to Customer	6. Review itemized estimate with customer. Answer any questions customer may have. **Key Point:** Once customer or insurance company okays estimate, you can prepare a work order, schedule the vehicle for repair, and have the customer sign.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied mathematics teacher could work with students on caculator use; calculating estimates accurately (e.g., addition and subtraction skills); and how to figure flat rate, commission pay vs. hourly, etc.

Review:

Ask students review questions such as the following:

1. To prepare an estimate, what information needs to be obtained from the customer?
2. What other information is needed to prepare the estimate?
3. Why is it important to use a systematic approach when analyzing damage?

Application:

1. Provide students with various vehicles, and ask them to identify basic information needed for preparing an estimate (e.g., make, model, year, VIN, paint code, date vehicle was built).
2. Divide students into pairs, and have them role-play greeting a customer and securing needed information in an estimating situation.
3. Give students an incomplete estimate, and have them use estimating manuals to supply the needed information.

Evaluation:

√ The student will prepare an estimate. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.9.

Competency 6.9: Prepare estimates

Performance Checklist

In preparing an estimate, the student—

	1	2	3	4	5
1. Followed prescribed safety procedures	☐	☐	☐	☐	☐
2. Selected correct tool(s) to use	☐	☐	☐	☐	☐
3. Greeted customer politely	☐	☐	☐	☐	☐
4. Obtained all needed information from customer, including—					
a. Customer's name, address, and phone number	☐	☐	☐	☐	☐
b. Make, model, and year of vehicle	☐	☐	☐	☐	☐
5. Located the following information:					
a. Vehicle Identification Number (VIN)	☐	☐	☐	☐	☐
b. Paint code	☐	☐	☐	☐	☐
c. Date vehicle was built	☐	☐	☐	☐	☐
6. Visually inspected vehicle, beginning with damage, and moving front to rear	☐	☐	☐	☐	☐
7. Identified all damage, including previous, unrelated damage; and hidden damage	☐	☐	☐	☐	☐
8. Used appropriate estimating manual to accurately identify—					
a. Cost of parts	☐	☐	☐	☐	☐
b. Body labor costs	☐	☐	☐	☐	☐
c. Paint labor costs	☐	☐	☐	☐	☐
d. Costs of non-included operations	☐	☐	☐	☐	☐
9. Prepared a complete written estimate, including—					
a. Complete itemized lists of parts, time, and materials	☐	☐	☐	☐	☐
b. Accurate calculations (subtotal, tax, total)	☐	☐	☐	☐	☐
c. Signature of preparer	☐	☐	☐	☐	☐
10. Reviewed estimate with customer and answered questions	☐	☐	☐	☐	☐

11. Maintained clean work area .... ☐ ☐ ☐ ☐ ☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________

Competency 6.10: Acquire parts

Competency Development Guide

Objective:

Condition:	Provided with a parts request
Behavior:	Acquire parts
Criteria:	In accordance with the criteria in the checklist for Competency 6.10

Introduction:

General Introductory Techniques: Share personal experiences you have had when acquiring parts in the collision repair facility. Show videos that demonstrate the steps in this process.

Competency-Specific Information:

1. Parts don't just miraculously appear. They have to be ordered.

2. Ask students for examples from their own experience in which a car couldn't be repaired because a needed part didn't arrive for a long time or the part received wasn't right.

3. It is the auto collision technician's responsibility to ensure that the parts person gets the correct information and that the part received for the vehicle is correct.

References:

Service manuals; technical service bulletins (TSBs). (See listings of standard references for the field, pp. 13–16, and auto-related Websites, pp. 6–11, in the "About This Guide" section.)

Presentation:

Good instruction provides instructional variety and involves both ***showing*** and ***telling.*** However, instructional settings (related vs. lab) and schedules vary. The following outline tells ***what***, in general, should be covered. ***How*** you structure this content to provide both verbal instruction and demonstration will have to be a local decision. See "About This Guide, p. 16, for more information.

Presentation Outline	Steps to Cover/Key Points to Make
1. Background Information	1. All necessary information must be available before picking up phone to contact parts person. Collect necessary information (e.g., make, model, year, VIN, option codes): • Location and meaning of VIN codes • Production plate on vehicle Identify additional damage after teardown (2.2.1).
2. Conveying Information to Parts Person	2. Telephone contact procedures (e.g., stating who you are, the company you represent, why you are calling) Telephone answering procedures (e.g., "Hello," "Thank you for calling," "How may I help you?")
3. Checking Price	3. Price used must be within customer estimate guidelines.
4. Checking Availability	4. Is the part available? If not, how long will it take to arrive?
5. Confirming Order on Receipt	5. Confirm that each part received is correct. If parts are delivered, confirm correct part(s) and note any discrepancies or damage before driver leaves.

Note: The lesson presentation should be coordinated with students' applied academics teachers to the extent possible.

For example, the applied communications teacher can work with students on communicating clearly, efficiently, and courteously via the telephone.

Review:

Ask students review questions such as the following:

1. What must you know before you pick up the phone to order a part?
2. Why is it necessary to ask for parts availability when ordering parts?
3. What must you do if the price of the part is greater than the estimate provided to the customer?

Application:

1. Provide pairs of students with a parts catalog, and have them role-play phone contacts, with one student playing the role of parts person and one student playing the role of collision technician seeking parts information.
2. ***With permission*** from local parts suppliers, allow students to call for "estimates" on vehicles they diagnose in the laboratory. Ask them to record all prices, quantities, part numbers, etc., on given repair estimate form.

Evaluation:

√ Each student will acquire parts. His/her performance will be evaluated using a copy of the performance checklist for Competency 6.10.

Competency 6.10: Acquire parts

Performance Checklist

In acquiring parts, the student—

	1	2	3	4	5
1. Referred to appropriate technical service bulletin(s)	☐	☐	☐	☐	☐
2. Collected all necessary information (e.g., make, model, year, VIN, additional damage after teardown)	☐	☐	☐	☐	☐
3. Conveyed information to parts person clearly and accurately	☐	☐	☐	☐	☐
4. Verified that price was within estimate guidelines	☐	☐	☐	☐	☐
5. Verified availability of part	☐	☐	☐	☐	☐
6. Confirmed that the correct part was received	☐	☐	☐	☐	☐

Overall competency rating: _____

Instructor's comments:

Student's name____**Date**______________